1.Units and Measurement

2 Marks Answers and Questions

Q1. Explain the following statement.

“To call a dimensional quantity ‘large’ or ‘small’ is meaningless without specifying a standard for comparison”.

Ans: The given statement is true because a dimensionless quantity can be large or small, but it must be compared to some standard. The coefficient of friction, for example, is dimensionless, but we can say that the coefficient of sliding friction is greater than the coefficient of rolling friction but less than the coefficient of static friction.

Q2. Explain this common observation clearly: If you look out of the window of a fast-moving train, the nearby trees, houses, etc., seem to move rapidly in a direction opposite to the train’s motion, but the distant objects (hilltops, the moon, the stars, etc.) seem to be stationary. (In fact, since you are aware that you are moving, these distant objects seem to move with you.)

Ans: The phenomenon observed in the above case refers to the line-of-sight. It is defined as an imaginary line joining an object and an observer’s eye. When we observe nearby stationary objects such as trees, houses, etc., while sitting in a moving train, they appear to move rapidly in the opposite direction because the line-of-sight changes very rapidly.

On the other hand, distant objects such as trees, stars, etc., appear stationary because of the large distance. As a result, the line-of-sight does not change its direction rapidly.

Q3. Precise measurements of physical quantities are a need of science. Comment.

(For example, to ascertain the speed of an aircraft, one must have an accurate method to find its positions at closely separated instants of time. This was the driving force behind the development of radar during World War II.

Ans: It is indeed very true that precise measurements of physical quantities are essential for the development of science. Some examples are:

Ultrashort laser pulses (time interval ∼10−15s) are used to measure time intervals in several physical and chemical processes.

X-ray spectroscopy is used to determine the interatomic separation or inter-planar spacing.

The development of the mass spectrometer makes it possible to measure the mass of atoms precisely.

Q4. Think of different examples in modern science where precise measurements of length, time, mass, etc., are needed. Also, give a quantitative idea of the precision needed, wherever possible.

Ans: It is indeed very true that precise measurements of physical quantities are essential for the development of science. Some examples are as follows.

1. Ultrashort laser pulses (time interval ∼10−15s) are used to measure time intervals in several physical and chemical processes.
2. X-ray spectroscopy is used to determine inter atomic separation or inter-planar spacing.
3. The development of the mass spectrometer makes it possible to measure the mass of atoms precisely.

Q5. A new length unit is chosen so that the speed of light in vacuum is unity.What is the new unit distance between the Sun and the Earth if light takes 8 minutes and 20 seconds to cover this distance?

Ans:The distance between the sun and the earth is given by:

x = speed of light/time required for light to travel the distance

We are given, in the new unit, the speed of light, c=1 unit

Time taken, t=8 min 20 s=500 s

∴ Distance between the Sun and the Earth $x'=c\times t'=1\times 500=500$ units

Q6. A student measures the thickness of a human hair using a microscope with a magnification of 100. He makes 20 observations and finds that the average width of the hair in the field of view of the microscope is 3.5 mm. Determine the thickness of your hair.

Ans:We are given:

Magnification of the microscope =100

Average width of the hair in the field of view of the microscope =3.5 mm

∴ Actual thickness of the hair would be, 3.5100= 0.035mm

Q6.A radar signal is beamed towards a planet from the earth and its echo is received seven minutes later. Calculate the velocity of the signal, if the distance between the planet and the earth is 10 6.3 10 m .

Ans: Time after which the echo is received, t 7min 7 60s .

Distance between the planet and earth, 10 x 6.3 10 m .

The net distance covered while the radar signal reaches the planet and echo to reach back to earth 2x .

We know that the velocity is defined as the net distance covered per total time taken.

So, c=2x/t

$C=2*6.3*10^{10}/7*60$

$C=3*10^8$ m / s

4 Marks Question and Answer

Q1. One mole of an ideal gas at standard temperature and pressure occupies 22.4L (molar volume). What is the ratio of molar volume to the atomic volume of a mole of hydrogen? (Take the size of the hydrogen molecule to be about 1A∘). Why is this ratio so large?

Ans:Radius of hydrogen atom, $r=0.5A^\circ=0.5\times10^{-10}m$

Volume of hydrogen atom, V= 43 r2

$\Rightarrow$ V= 43 227 $(0.5\times10^{-10})^3=0.524\times10^{-30}m^3$

Now, 1 mole of hydrogen contains 6.023×10^{23} hydrogen atoms.

$\therefore$ Volume of 1 mole of hydrogen atoms, $V_a=6.023\times10^{23}\times0.524\times10^{-30}=3.16\times10^{-7}m^3$

Molar volume of 1 mole of hydrogen atoms at STP,

$V_m=22.4L=22.4\times10^{-3}m^3$

So, the required ratio would be,

VmVa= 22.4 10-33.16 10-7= 7.08 104

Hence, we found that the molar volume is 7.08×10^4 times higher than the atomic volume. For this reason, the inter atomic separation in hydrogen gas is much larger than the size of a hydrogen atom.

7 Marks Answers and Questions

Q1: Just as precise measurements are necessary in Science; it is equally important to be able to make rough estimates of quantities using rudimentary ideas and common observations. Think of ways by which you can estimate the following (where an estimate is difficult to obtain, try to get an upper bound on the quantity):

- **The Total Mass of Rain-Bearing Clouds Over India During the Monsoon.**

Ans:For estimating the total mass of rain-bearing clouds over India during the Monsoon:

During monsoons, a meteorologist records about 215 cm of rainfall in India, i.e., the height of the water column, h=215 cm=2.15 m

We have the following information,

Area of country, $A=3.3\times10^{12}m^2$

Hence, the volume of rainwater, $V=A\times h=7.09\times10^{12}m^3$

Density of water, $\rho=1\times10^3 kg\ m^{-3}$

We can find the mass from the given value of density and volume as,

$M=\rho\times V=7.09\times1015kg$

Hence, the total mass of rain-bearing clouds over India is approximately found to be $7.09\times1015kg$

1. The Mass of an Elephant.

Ans:

For estimating the mass of an elephant:

Consider a ship floating in the sea whose base area is known. Measure its depth at sea (say d1).

Volume of water displaced by the ship would be, $Vb=Ad1$

Now one could move an elephant on the ship and then measure the depth of the ship (d2).

Let the volume of water displaced by the ship with the elephant on board be given as $Vbe=Ad2$.

Then the volume of water displaced by the elephant $=Ad2-Ad1$.

If the density of water $=D$

Mass of an elephant would be $M=AD(d2-d1)$.

2. The Wind Speed During a Storm.

Ans: Estimation of wind speed during a storm:

Wind speed during a storm can be measured by using an anemometer. As wind blows, it rotates and the number of rotations in one second as recorded by the anemometer gives the value of wind speed.

3. The Number of Strands of Hair on Your Head.

Ans: Estimation of the number of strands of hair on your head:

Let the area of the head surface carrying hair be A

The radius of a hair can be determined with the help of a screw gauge and let it be r

$\therefore$ Area of one hair strand $=\pi r2$

Number of strands of hair ≈ Total surface Area of one hair = ar2

4. The Number of Air Molecules in Your Classroom.

Ans:

Estimation of the number of air molecules in your classroom:

Let the volume of the room be V

We know that:

One mole of air at NTP occupies 22.4 l

i.e., 22.4×10−3m3 volume.

Number of molecules in one mole NA=6.023×1023 (Avogadro number)

∴ Number of molecules in room of volume(V) could be found as,

n= 6.023 102322.410-3

⇒n=134.915×1026V

∴n=1.35×1028V

Q2. In a test to determine the size of an oleic acid molecule In 19 mL of alcohol, 1 mL of oleic acid is dissolved. Then, using alcohol, dilute 1 mL of this solution to 20 mL. Now, 1 drop of this diluted solution is dropped into a shallow trough of water. The solution forms a one-molecule thick film on the water's surface. The film is now uniformly dusted with lycopodium powder, and its diameter is measured. We can compute the thickness of the film using the volume of the drop and the area of the film, which will give us the size of the oleic acid molecule.

Answer the following questions after carefully reading the passage:

a. **Why is oleic acid dissolved in alcohol?**
b. **What role does lycopodium powder play?**
c. **How much oleic acid would be in each mL of the solution prepared?**
d. **In what way will you determine the volume of n drops of oleic acid solution?**
e. **How much oleic acid will be in one drop of this solution?**

Ans. (a) Oleic acid is dissolved in alcohol since it does not dissolve in water.

(b) When uniformly dusted, lycopodium powder covers the whole surface of the water.

Oleic acid does not dissolve in water when a drop of the prepared solution is placed on it. Instead, it spreads over the water's surface, pushing the lycopodium powder away from the drop's landing place. As a result, we can calculate the area covered by oleic acid.

(c) The volume of oleic acid in each mL of the solution made = 1/20mL*1/20=1/400mL

(d) A burette and measuring cylinder may be used to compute the volume of n droplets of this oleic acid solution, and the number of drops can be counted.

(e) If n drops of the solution equal 1 mL, the amount of oleic acid in one drop is $1/(400)^{n}$ mL.