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Answers Key:

5 Marks

1. Given, molar volume of one mole of hydrogen
   = 22.4 L = $22.4 \times 10^{-3} m^3$
   Diameter of hydrogen molecules (d) = $1\mathring{A}$ = 10^{-10}m
   $\therefore$ Radius of hydrogen molecule (r) = $\frac{d}{2} = \frac{10^{-10}}{2}$
   $= 0.5 \times 10^{-10} m$
   Volume of one molecule of hydrogen = $\frac{4}{3}\pi r^3$
   $= \frac{4}{3} \times 3.14 \times (0.5 \times 10^{-10})$
   $= 5.234 \times 10^{-31} m^3$
   Number of molecules in one mole hydrogen = Avogadro's number (N) = 6.023×10^{23}
   $\therefore$ Atomic volume of one mole of hydrogen = Number of molecules in one mole of hydrogen $\times$ Volume of one molecule of hydrogen
   $= 6.023 \times 10^{23} \times 5.234 \times 10^{-31}$
   $= 3.152 \times 10^{-7} m^3$
   $\therefore \frac{Molar\ Volume}{Atomic\ Volume} = \frac{22.4 \times 10^{-3}}{3.152 \times 10^{-7}} = 7.1 \times 10^4$
   This ratio is very large, which shows that the intermolecular separation in a gas is much larger than the size of a molecule.
2. Given, Mass of the Sun =$2.0 \times 10^{30} kg$
   Radius of the Sun =$7.0 \times 10^8 m$
   Density of the Sun = $\frac{Mass\ of\ the\ Sun\ (M)}{Volume\ of\ the\ Sun\ (S)}$
   $\left[\therefore \text{Density} = \frac{Mass}{Volume}\right]$
   $\rho = \frac{M}{\frac{4}{3}\pi R^3} = \frac{3}{4}\frac{M}{\pi R^3}$
   $= \frac{3 \times 2.0 \times 10^{30}}{4 \times 3.14 \times (7.0 \times 10^8)^3}$
   $= \frac{3 \times 10^{30}}{6.28 \times 343 \times 10^{24}}$
   $= 1.392 \times 10^3$
   $\rho \approx 1.4 \times 10^3 kg/m^3$
   This density is the order of density of solids and liquids and not of gases.
   The temperature of inner core of the sun is 10^7 K while the temperature of the outer layers is nearly 6000 K. At so high temperature, no matter can be exist in its solid or liquid state.
   Every matter is highly ionised and present as a mixture of nucleus, free electr4onbs and ions which is called plasma. The density of plasma is so high due to inward gravitational attraction on outer layers due o inner layers of the sun.
3. The statement is true. Any dimensional physical quantity can be called large or small by specifying a standard for comparison. e.g., the mass of a boy is 40 Kg, which is very small in comparison to the mass of the earth (6 x 10^{24} kg) but very large in comparison to the mass of an electron (9.1 x 10^{-31} kg).
   (i) The size of an atom is very small in comparison to the size of a sugar cube.
   (ii) A jet plane moves faster than a superfast train.
   (iii) The mass of Jupiter is very large as compared to the mass of Uranus.
   (iv) The air inside this room contains large number of molecules than in one mole of air.
   (v) The statement is already correct
   (vi) The statement is already correct
4. The dependence of time period T on the quantities l, g and m as a product may be written as :
   $T = km^x l^y g^z$
   where k is dimensionless constant and x, y and z are the exponents.
   By considering dimensions on both sides, we have
   $\left[L^0 M^0 T^1\right] = \left[L^1\right]^x \left[L^1 T^{-2}\right]^y \left[M^1\right]^z = L^{x+y} T^{-2y} M^z$
   On equating the dimensions on both sides,
   we have x + y = 0; –2y = 1; and z = 0
   So, that x = $\frac{1}{2}$, y = $-\frac{1}{2}$, z = 0
   Then $T = km^0 l^{1/2} g^{-1/2}$ or, $T = k\sqrt{\frac{l}{g}}$
   Note that value of constant k can not be obtained by the method of dimensions. Here it does not matter if some number multiplies the right side of this formula, because that does not affect its dimensions.
   Actually, k = 2π so tha $T = 2\pi\sqrt{\frac{l}{g}}$
5. The instrument whose least count is minimum, is called the most precise device.
   i) Number of divisions on vernier scale = 20
   Main scale Division (MSD) = 1 mm
   As 20 divisions on vernier scale will be equal to the 19 divisions on the vernier scale will be equal to the 19 division on main scale.
   $\therefore$ vernier scale Division (VSD) = $\frac{19}{20} MSD$
   Least count of vernier callipers
   = 1MSD – 1VSD
   $= 1MSD - \frac{19}{20} MSD = \frac{1}{20} MSD$
   $= \frac{1}{20} mm = \frac{1}{200} cm = 0.005 cm$
   ii) Pitch of screw guage = 1mm
   Number of divisions on circular scale = 100

Least count of screw guage

$= \frac{Pitch}{Number\ of\ division\ on\ circular\ scale}$

$= \frac{1}{100} mm = \frac{1}{1000} cm = 0.001 cm$

iii) Wavelength of light $(\lambda) \approx 10^{-7} m$

= 10^{-5}cm = 0.00001 cm

$\therefore$ As the given optical instrument can measure length to within a wavelength of light, therefore, least count of the given optical instrument

= Wavelength of light

= 0.00001 cm

The least count is minimum for the given optical instrument. Therefore, the given optical instrument is the most precise.

6. The dimensional formula of energy = $[ML^2T^{-2}]$

Let M_1 ,L_1, T_1 and M_2 ,L_2 ,T_2 are the units of mass, length and time in given two systems

$M_1 = 1\ kg, \quad M_2 = \alpha\ kg$

$L_1 = 1\ m, \quad L_2 = \beta\ m$

$T_1 = 1\ s, \quad T_2 = \gamma\ s$

For any physical quantity, the product of its magnitude and unit is always constant

$n_1 u_1 = n_2 u_2$

$or\ n_2 = n_1 \frac{u_1}{u_2} = 4.2 \times [\frac{[M_1 L_1^2 T_1]}{[M_2 L_2^2 T_2^{-2}]}$

$= 4.2 \left[\frac{M_1}{M_2}\right] \times \left[\frac{L_1}{L_2}\right]^2 \times \left[\frac{T_1}{T_2}\right]^{-2}$

$= 4.2 \left[\frac{1}{\alpha}\right] kg \times \left[\frac{1}{\beta} m\right]^2 \left[\frac{1}{\gamma} s\right]^{-2}$

$n_2 = 4.2\alpha^{-1}\beta^{-2}\gamma^2$ new unit

$\therefore\ 1\ cal = 4.2\alpha^{-1}\beta^{-2}\gamma^2$ new unit

3 Marks

7. Given, Angular diameter, $\theta = 1920''$

Distance of the sun from earth, $r = 1.496 \times 10^{11} m$

The diameter of the sun, d = ?

$\theta = 1920'' = 1920 \times 4.85 \times 10^{-6} rad$

= 9.31×10^{-3} rad

We know that, $d = \theta r$

$d = 9.31 \times 10^{-3} \times 1.496 \times 10^{11} = 1.39 \times 10^9 m$

Thus, the diameter of the sun is $1.39 \times 10^9 m$

8. The number of significant figures in the given quantities are given below.

(i) In 0.007, the number of significant figures is 1 because in a number less than 1, the zero's on the right of the decimal point but to the left of the first non-zero digit are not significant.

(ii) In 2.64 × 10^{24} kg, the number of significant figures is 3 because all non-zero digits are significant, power of 10 are not taken in significant figure.

(iii) In 0.2370, the number of significant figures is 4, as all non-zero digits left to decimal and trailing zero are significant.

(iv) In 6.320, the number of significant figures is 4, as all non-zero digits left to decimal and trailing zero are significant.

(v) In 6.032, the number of significant figures is 4, as all non-zero digits left to decimal and trailing zero are significant.

(vi) In 0.0006032, the number of significant figures is 4, because in a number less than 1, the zero's on the right of the decimal point but to the left of the first non-zero digit are not significant.

9. (a) 5238 N has four significant digits.

(b) 4200 kg = $4.200 \times 10^3 kg$ has four significant figures.

(c) 34.000 m has five significant digits.

(d) 0.02340 N/m has four significant figures.

10. Given, r = 824.7 x 10^6 km

$\theta = 35.72'' = \frac{35.72}{60X60} = \frac{\pi}{180} rad$

Diameter, l = ?

As, l = $r\theta \Rightarrow l = 824.7 \times 10^6 \times \frac{35.72X\pi}{60\times60\times180} km$

$= 1.429 \times 10^5 Km$

11. Given, Length (l) = 4.234 m

Breadth (b) = 1.005 m

Thickness (t) = 2.01 cm = 0.0201 m

Area of sheet (A) = $2(l \times b + b \times t + t \times l)$

$= 2\left[(4.234 \times 1.005) + (1.005 \times 0.0201) + (0.0201 \times 4.234)\right]$

$= 2 \times 4.3604739$

$= 8.7209578 m^2$

As, thickness has least number of significant figures 3, therefore, rounding off area up to the three significant figures, we get

Area of sheet (A) = $8.72m^{-2}$

Volume of sheet (V) = $l \times b \times h$

= $4.234 \times 1.005 \times 0.0201$

= 0.0855289

Rounding off up to three significant figures, we get Volume of the sheet = $0.0855m^3$.

12. Given, mass of the box (m) = 2.3 Kg

mass of first gold piece (m_1) = 20.15 g = 0.02015 Kg

Mass of second gold piece (m_2) = 20.17 g = 0.02017 Kg

Difference in masses of gold pieces ($\triangle m$) = m_2 - m_1

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= 20.17 - 20.15 = 0.02 g
(The masses of two gold pieces has two decimal places, therefore, it is correct up to two places of decimal)

13. 101.6×10^6

14. The number of significant figures in the measured length is 4. The calculated area and the volume should therefore be rounded off to 4 significant figures.
Surface area of the cube = $6(7.203)^2$ m^2
= 311.299254 m^2
= 311.3 m^2
Volume of the cube = $(7.203)^3$ m^3
= 373.714754 m^3
= 373.7 m^3

15. There are 3 significant figures in the measured mass whereas there are only 2 significant figures in the measured volume. Hence the density should be expressed to only 2 significant figures
Density = $\frac{5.74}{1.2} gcm^{-3}$
= 4.8 g cm^{--3} .

16. In mechanics length, mass and time are chosen as base quantities because
(i) there is nothing simpler to length, mass and time.
(ii) all other quantities in mechanics can be expressed in terms of length, mass and time.
(iii) length, mass and time cannot be derived from one another.

17. Average distance of earth from the sun in (i) light year (ii) par sec
Average distance of earth from the sun is (r)
i.e r = 1AU = 1.496 x 10^{11}m
$= \frac{1.496 \times 10^{11}}{9.46 \times 10^{15}}$ly = 1.58 x 10^{-5} ly
Also, r = $\frac{1.496 \times 10^{11}}{3.08 \times 10^{16}}$ par sec
= 4.86 x 10^{-6} par sec

18. Every correct formula or equation must have the same dimensions on both sides of the equation. Also, only quantities with the same physical dimensions can be added or subtracted. The dimensions of the quantity on the right side are [M^2 L^3 T–3] for (a); [M L^2 T^{-2}] for (b) and (d); [M L T^{-2}] for (c). The quantity on the right side of (e) has no proper dimensions since two quantities of different dimensions have been added. Since the kinetic energy K has the dimensions of [M L^2 T^{-2}], formulas (a), (c) and (e) are ruled out. Note that dimensional arguments cannot tell which of the two, (b) or (d), is the correct formula. For this, one must turn to the actual definition of kinetic energy (see Chapter 5). The correct formula for kinetic energy is given by (b).

19. Radius of a hydrogen atom(r) = 0.5A = 0. 5 x 10^{-10}m
Volume of each hydrogen atom (v) = $\frac{4}{3}\pi r^3$
$\frac{4}{3} \times 3.14 \times \left(0.5 \times 10^{-10}\right) = 5.234 \times 10^{-31} m^3$
Number of atom in 1 mole of hydrogen =Avogadro's number (N)
= 6.023 x 10^{23}
Atomic volume of 1 mole of hydrogen atoms (v′)
= volume of a hydrogen atom X number of atoms
V′ = V x N

20. Second has been defined in terms of periods of radiation, because
(i) this period is accurately defined.
(ii) this period is not affected by a change of physical conditions like temperature, pressure and volume etc.
(iii) the unit is easily reproducible in any good laboratory.

21. (a) Wrap the thread a number of times on a round pencil so as to form a coil having its turns touching each other closely. Measure the length of this coil, mode by the thread, with a metre scale. If n be the number of turns of the coil and l be the length of the coil, then the length occupied by each single turn i.e., the thickness of the thread = 1/n. This is equal to the diameter of the thread.
(b) It is not possible to increase the accuracy of a screw gauge by increasing the number of divisions of the circular scale. Increasing the number divisions of the circular scale will increase its accuracy to a certain extent only.
(c) Due to random errors, a large number of observation will give a more reliable result than smaller number of observations. This is due to the fact that the probability (chance) of making a positive random error of a given magnitude is equal to that of making a negative random error of the same magnitude. Thus in a large number of observations, positive and negative errors are likely to cancel each other. Hence more reliable result can be obtained.

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