2.1 Fill in the blanks

(a) The volume of a cube of side 1 cm is equal to …..m^3

Ans:

1 cm = $\frac{1}{100}$ m

Volume of the cube = a^3

= $\frac{1}{100}$ m $\times$ $\frac{1}{100}$ m $\times$ $\frac{1}{100}$ m

= 0.01

Therefore, the volume = 0.01

(b) The surface area of a solid cylinder of radius 2.0 cm and height 10.0 cm is equal to …(mm)^2

Ans:

Surface area of a cylinder = $2\pi r(r + h)$

r = 2 x 10 mm = 20 mm

h = 10 x 10 mm = 100 mm

Surface area = 2 x 3.14 x 20 x (20 + 100) = 16320 = 1.6 x 10^4 mm^2.

(c) A vehicle moving with a speed of 18 km h–1 covers….m in 1 s

Ans:

The speed of the car is said to be 18 km/hr = 18 x 1000/3600 meter/second

=> 5 m/s, this means that the car covers 5 meters in one second = 11.3

(d) The relative density of lead is 11.3. Its density is ….g cm–3 or ….kg m–3.

Ans:

The Relative density of lead is 11.3 g cm^{-3}

=> 11.3 x 10^3 kg m^{-3} [1 kilogram = 10^3g, 1 meter = 10^2 cm]

=> 11.3 x 10^3 kg m^{-4}

2.2 Fill in the blanks by suitable conversion of units

(a) 1 kg m^2 s^{-2} = ...g cm^2 s^{-2}

(b) 1 m = ... ly
(c) 3.0 m s^{-2} = ... km h^{-2}
(d) G = 6.67×10^{-11} N m^2 $(kg)^{-2}$ = ... (cm)3s^{-2} g^{-1}
Ans:

(a) 1 kg m^2 s^{-2} = ...g cm^2 s^{-2}

1 kg m^2 s^{-2} = 1kg x 1m^2 x 1s^{-2}

We know that,

1kg = 10^3

1m = 100cm = 10^2cm

When the values are put together, we get:

1kg x 1m^2 x 1s^{-2} = 10^3g x $(10^2cm)^2$ x 1s^{-2} = 10^3g x 10^4 cm^2 x 1s^{-2} = 10^7 g$cm^2$$s^{-2}$

=>1kg m^2 s^{-2} = 10^7 g$cm^2$$s^{-2}$

(b) 1 m = ... ly

Using the formula,

Distance = speed x time

Speed of light = 3 x 10^8 m/s

Time = 1 yr = 365 days = 365 x 24 hr = 365 x 24 x 60 x 60 sec

Put these values in the formula mentioned above, we get:

One light year distance = (3 x 10^8 m/s) x (365 x 24 x 60 x 60) = 9.46×10^{15}m

9.46 x 10^{15} m = 1ly

So that, 1m = 1/9.46 x 10^{15}ly

=> 1.06 x 10^{-16}ly

=>1 meter = 1.06 x 10^{-16}ly

(c) 3.0 m s^{-2} = ... km h^{-2}

1 km = 1000m so that 1m = 1/1000 km

3.0 m s^{-2} = 3.0 (1/1000 km) (1/3600 hour) $^{-2}$ = 3.0 x 10^{-3} km x ($(1/3600)^{-2}$$h^{-2}$)

= 3 x 10^{-3}km x $(3600)^2$ hr^{-2} = 3.88 x 10^4 km h^{-2}

=> 3.0 m s^{-2} = 3.88 x 10^4 km h^{-2}

(d) $G = 6.67 \times 10^{-11}$ N m^2 (kg)$^{-2}$ = ... (cm)3s^{-2} g^{-1}

$G = 6.67 \times 10^{-11}$ N m^2 (kg)$^{-2}$

We know that,

1N = 1kg m s^{-2}

1 kg = 10^3 g

1m = 100cm= 10^2 cm

Put the values together, we get:

=> 6.67×10^{-11} Nm^2 kg^{-2} = 6.67×10^{-11} x (1kg m s^{-2}) (1m^2) (1kg^{-2})

Solve the following and cancelling out the units, we get:

=> 6.67×10^{-11} x (1kg^{-1} x 1m^3 x 1s^{-2})

Put the above values together to convert kg to g and m to cm

=> 6.67×10^{-11} x (10^3g)$^{-1}$ x (10^2 cm)^3 x (1s^{-2})

=> 6.67×10^{-8} cm^3 s^{-2} g^{-1}

=>G = 6.67×10^{-11} Nm^2(kg)$^{-2}$ = 6.67×10^{-8} (cm)^3 s^{-2} g^{-1}

2.3 A calorie is a unit of heat (energy in transit) and it equals about 4.2 J where 1J = 1 kg m^{2}s^{-2}. Suppose we employ a system of units in which the unit of mass equals α kg, the unit of length equals β m, the unit of time is γ s. Show that a calorie has a magnitude 4.2 $\alpha^{-1} \beta^{-2} \gamma^2$ in terms of the new units

Ans: 1 calorie = 5.2 (1kg) (1m^2) (1 s^{-2})

New unit of mass = α kg

Then, 1 kg = $\frac{1}{\alpha}$ = α^{-1}

New unit of length = $\frac{1}{\beta}$ = β^{-1} or 1 m^2 = β^{-2}

New unit of time = $\frac{1}{\gamma}$ = γ^{-1}

$1\ s^2 = \gamma^{-2}$

$1\ s^2 = \gamma^2$

Therefore, 1 calorie = $5.2\ \alpha\ \beta^{-2}\ y^2$.

2.4 Explain this statement clearly :
"To call a dimensional quantity 'large' or 'small' is meaningless without specifying a standard for comparison". In view of this, reframe the following statements wherever necessary:
(a) atoms are very small objects
(b) a jet plane moves with great speed
(c) the mass of Jupiter is very large
(d) the air inside this room contains a large number of molecules
(e) a proton is much more massive than an electron
(f) the speed of sound is much smaller than the speed of light.(a) Atoms are small object
Ans:
(a) In comparison with a soccer ball, atoms are very small
(b) When compared with a bicycle, jet plane travels at high speed.
(c) As compared with the air inside a lunch box, the air inside the room has a large number of molecules.
(d) When compared with the mass of a cricket ball, the mass of Jupiter is very large.
(e) Like comparing the speed of a bicycle and a jet plane, the speed of light is more than the speed of sound.
(f) A proton is massive when compared with an electron.

2.5 A new unit of length is chosen such that the speed of light in vacuum is unity. What is the distance between the Sun and the Earth in terms of the new unit if light takes 8 min and 20 s to cover this distance?
Ans:
Distance between them = Speed of light x Time taken by light to cover the distance
Speed of light = 1 unit
Time taken = 570 s
The distance between Sun and Earth = 1 x 570 = 570 units.

2.6 Which of the following is the most precise device for measuring length :

(a) a vernier callipers with 20 divisions on the sliding scale
(b) a screw gauge of pitch 1 mm and 100 divisions on the circular scale
(c) an optical instrument that can measure length to within a wavelength of light ?

Ans:

(a) Least count = $1- \frac{9}{10} = \frac{1}{10}$ = 0.01cm

(b) Least count = $\frac{pitch}{number of divisions}$

= $\frac{1}{10000}$ = 0.001 cm

(c) least count = wavelength of light = 10^{-5} cm

= 0.00001 cm

We can come to the conclusion that the optical instrument is the most precise device used to measure length.

2.7 A student measures the thickness of a human hair by looking at it through a microscope of magnification 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. What is the estimate on the thickness of the hair?

Ans:

Microscope magnification = 200

The average width of hair under the microscope = 4.5 mm

Average thickness of hair = $\frac{4.5}{200}$ = 0.0225 mm.

2.8 Answer the following:
(a)You are given a thread and a metre scale. How will you estimate the diameter of the thread?
(b)A screw gauge has a pitch of 1.0 mm and 200 divisions on the circular scale. Do you think it is possible to increase the accuracy of the screw gauge arbitrarily by increasing the number of divisions on the circular scale?
(c) The mean diameter of a thin brass rod is to be measured by vernier callipers. Why is a set of 100 measurements of the diameter expected to yield a more reliable estimate than a set of 5 measurements only?

Ans:

(a)You are given a thread and a metre scale. How will you estimate the diameter

of the thread?

Take the thread and wrap it around a rod in such a way that the coil turns are very close to each other. Measure the whole length of the thread.

Diameter = $\frac{Length\ of\ thread}{number\ of\ turns}$

(b) A screw gauge of circular scale has a pitch of 1 mm and 200 division. By increasing the number of divisions on the circular scale can the accuracy be increased?

Ans:

Even if the number of divisions on the circular scale is increased, the accuracy will not be increased. The accuracy will increase only to a certain extent if the number of divisions is increased.

(c) Vernier calliper is used to measure the mean diameter of the iron rod. A more reliable estimate is got from a set of 200 measurements when compared with a set of 10 measurements. Why is that?

Ans:

A reliable estimate is got from a set of 200 measurements as the random errors involved are less when compared with the set of 10 measurements.

2.9 The photograph of a house occupies an area of 1.75 cm^2 on a 35 mm slide. The slide is projected on to a screen, and the area of the house on the screen is 1.55 m^2. What is the linear magnification of the projector-screen arrangement?

Ans:

Area of the house in the photo = 2.75 cm^2

Area of the house on the screen = 2.45 m^2 = 2.45 x 10^4 cm^2

Arial magnification, $m_a = \frac{Area\ of\ image}{area\ of\ object} = \frac{2.45}{2.75} \times 10^4$

Linear magnification $m_1 = \sqrt{m_a} = \sqrt{\frac{2.45}{2.75} \times 10^4} = 94.38$

2.10 State the number of significant figures in the following:

(a) 0.007 m^2

(b) 2.64 × 10^{24} kg

(c) 0.2370 g cm^{-3}

(d) 6.320 J

(e) 6.032 N m^{-2}
(f) 0.0006032 m^2
Ans:
(a) 0.007 m^2
The given value is 0.007 m^2.
The given number is below one so the zeros on the right to the decimal are insignificant. So, the number 7 is the only significant figure in the following.

(b) 2.64 × 10^{24} kg
Ans:
The value is 2.64 × 10^{24} kg
For the determination of significant values, the power of 10 is irrelevant. The digits 2, 6, and 4 are significant figures.

(c) 0.2370 g cm^{-3}
Ans:
The value is 0.2370 g cm^{-3}
For the given value with decimals, all the numbers 2, 3, 7, and 0 are significant.

(d) 6.320 J
Ans:
For the given values, the trailing zeros are also significant. Therefore, all the five digits including the zeros are significant.

(e) 6.032 N m^{-2}
Ans:
All the five digits are significant as the zeros in between two non-zero values are also significant.

(f) 0.0006032 m^2
Ans:
Since the given value is below one, the zeros on the right side of the decimals are insignificant. The other five digits 6, 0, 3, and 2 are significant values as the zeros in-between two non-zeros are also significant.

2.11 The length, breadth and thickness of a rectangular sheet of metal are 4.234 m, 1.005 m, and 2.01 cm respectively. Give the area and volume of the sheet to correct significant figures.
Ans:

Length = 4.325 m
Breadth = 1.402 m
Height = 3.12 m = 0.0312 m
The length has 4 significant figures
The breadth has 4 significant figures
The height has 3 significant figures
Surface area formulae = 2(l x b + b x h + h x l)
= 2(4.325 x 1.402 + 1.402 x 0.0312 + 0.0312 x 4.325)
=2(6.06365 + 0.0437424 + 0.13494)
= 2 x 6.2423
=12.484 m^2

Volume = l x b x h
= 4.325 x 1.402 x 0.0312
= 0.189 m^3
The volume has three significant values 1, 8 and 9.
The area has five significant values 1, 2, 4, 8 and 4.

2.12 The mass of a box measured by a grocer's balance is 2.30 kg. Two gold pieces of masses 20.15 g and 20.17 g are added to the box. What is
(a) the total mass of the box,
(b) the difference in the masses of the pieces to correct significant figures?
Ans:
The mass of the box = 2.30 kg
and the mass of the first gold piece = 20.15 g

The mass of the second gold piece = 20.17 g
The total mass = 2.300 + 0.2015 + 0.2017 = 2.7032 kg

Since 1 is the least number of decimal places, the total mass = 2.7 kg.
The mass difference = 20.17 – 20.15 = 0.02 g
Since 2 is the least number of decimal places, the total mass = 0.02 g.

2.13 A physical quantity P is related to four observables a, b, c and d as follows:

$$P = \frac{a^3 b^2}{\sqrt{cd}}$$

The percentage errors of measurement in a, b, c and d are 1%, 3%, 4% and 2%, respectively. What is the percentage error in the quantity P? If the value of P calculated using the above relation turns out to be 3.763, to what value should you

round off the result?

Ans:

$\frac{a^3b^2}{\sqrt{c}d}$ $\frac{\Delta P}{P} = \frac{3\Delta a}{a} + \frac{2\Delta b}{b} + \frac{1}{2} \frac{\Delta c}{c} + \frac{\Delta d}{d}$

$\left(\frac{\Delta P}{P} \times 100 \right) \% = \left(3 \times \frac{\Delta a}{a} \times 100 + 2 \times \frac{\Delta b}{b} \times 100 + \frac{1}{2} \frac{\Delta c}{c} \times 100 + \frac{\Delta d}{d} \times 100 \right) \%$

$= 3 \times 1 + 2 \times 3 + \frac{1}{2} \times 4 + 2$

$= 3 + 6 + 2 + 2 = 13\ \%$

P = 4.235

ΔP = 13 % of P

$= \frac{13P}{100}$

$= \frac{13 \times 4.235}{100}$

= 0.55

The error lies in the first decimal point, so the value of p = 4.3

2.14 A book with many printing errors contains four different formulas for the displacement y of a particle undergoing a certain periodic motion:

(a) y = a sin ($\frac{2\pi t}{T}$)

(b) y = a sin vt

(c) y = $\frac{a}{T}$ sin $\frac{t}{a}$

(d) y = $a\sqrt{2}$ (sin $\frac{2\pi t}{T}$ + cos $\frac{2\pi t}{T}$)

Ans:

(a) y = a sin $\frac{2\pi t}{T}$

Dimension of y = $M^0 L^1 T^0$

The dimension of a = $M^0 L^1 T^0$

Dimension of sin $\frac{2\pi t}{T}$ = $M^0 L^0 T^0$

Since the dimensions on both sides are equal, the formula is dimensionally correct.

(b) It is dimensionally incorrect, as the dimensions on both sides are not equal.

(c) It is dimensionally incorrect, as the dimensions on both sides are not equal.

(d) y = $a\sqrt{2}$ (sin $\frac{2\pi t}{T}$ + cos $\frac{2\pi t}{T}$)

Dimension of y = $M^0 L^1 T^0$

The dimension of a = $M^0 L^1 T^0$

Dimension of $\frac{t}{T}$ = $M^0 L^0 T^0$

The formula is dimensionally correct.

2.15 A famous relation in physics relates 'moving mass' m to the 'rest mass' mo of a particle in terms of its speed v and the speed of light, c. (This relation first arose as a consequence of special relativity due to Albert Einstein). A boy recalls the relation almost correctly but forgets where to put the constant c. He writes:

m = $\frac{m_0}{\sqrt{1-\nu^2}}$

Guess where to put the missing c.

Ans:

The relation given is $\frac{m_0}{\sqrt{1-\nu^2}}$

We can get, $\frac{m_0}{m}$ = $\sqrt{1-\nu^2}$ $\frac{m_0}{m}$ is dimensionless. Therefore, the right hand side should also be dimensionless.

To satisfy this, $\sqrt{1-\nu^2}$ should become $\sqrt{1-\frac{\nu^2}{c^2}}$.

Thus, m = $m_0\sqrt{1-\frac{\nu^2}{c^2}}$.

2.16 The unit of length convenient on the atomic scale is known as an angstrom and is denoted by Å: 1 Å = 10^{-10} m. The size of a hydrogen atom is about 0.5 Å. What is the total atomic volume in m^3 of a mole of hydrogen atoms?

Ans:

hydrogen atom radius = 0.5 A = 0.5 x 10^{-10} m

Volume = $\frac{4}{3}\pi r^3$

= $\frac{4}{3}$ x $\frac{22}{7}$ x $(0.5 \times 10^{-10})^3$

= 0.524 x 10^{-30} m^3

1 hydrogen mole contains 6.023 x 10^{23} hydrogen atoms.

Volume of 1 mole of hydrogen atom = 6.023 x 10^{23} x 0.524 x 10^{-30}

= 3.16 x 10^{-7} m^3.

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

Ans:

Radius = 0.5 A = 0.5 x 10^{-10} m

Volume = $\frac{4}{3}\pi r^3$

= $\frac{4}{3}$ x $\frac{22}{7}$ x $(0.5 \times 10^{-10})^3$

= 0.524 x 10^{-30} m^3

1 hydrogen mole contains 6.023 x 10^{23} hydrogen atoms.

Volume of 1 mole of hydrogen atom = $6.023 \times 10^{23} \times 0.524 \times 10^{-30}$

$= 3.16 \times 10^{-7}\ m^3$

$V_m = 24.2\ L = 22.4 \times 10^{-3}\ m^3$

$\frac{V_m}{V_a} = \frac{24.2 \times 10^{3}}{3.16 \times 10^{-7}} = 7.65 \times 10^4$

The molar volume is 7.65×10^4 times more than the atomic volume. Hence, the inter-atomic separation in hydrogen gas is larger than the size of the hydrogen atom.

2.18 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:

An imaginary line which joins the object and the observer's eye is called the line of sight. When we observe the nearby objects, they move fast in the opposite direction as the line of sight changes constantly. Whereas, the distant objects seem to be stationary as the line of sight does not change rapidly.

2.19 The principle of 'parallax' in section 2.3.1 is used in the determination of distances of very distant stars. The baseline AB is the line joining the Earth's two locations six months apart in its orbit around the Sun. That is, the baseline is about the diameter of the Earth's orbit ≈ 3×10^{11}m. However, even the nearest stars are so distant that with such a long baseline, they show parallax only of the order of 1" (second) of arc or so. A parsec is a convenient unit of length on the astronomical scale. It is the distance of an object that will show a parallax of 1" (second of arc) from opposite ends of a baseline equal to the distance from the Earth to the Sun. How much is a parsec in terms of metres?

Ans:

The diameter of earth's orbit = 3×10^{11}m

The radius of earth's orbit, r = 1.5×10^{22}m

Let the distance parallax angle be 1″ = 4.847×10^{-6} rad

Let the distance of the star be D

Parsec is defined as the distance at which the average radius of the earth's orbit subtends an angle of 1″.

We can say that, $\theta = r/D$

$D = r/\theta = 3.09 \times 10^{26}$m = 1 parsec

2.20 The nearest star to our solar system is 4.29 light-years away. How much is this distance in terms of parsecs? How much parallax would this star (named Alpha Centauri) show when viewed from two locations of the Earth six months apart in its orbit around the Sun?

Ans:

The distance of the solar system from the star = 5.32 ly

1 light year = light speed x 1 year

$= 3 \times 10^8 \times 365 \times 24 \times 60 \times 60$

$= 94608 \times 10^{11}$ m

5.32 ly = 503314.56×10^{11} m

1 parsec = 3.08×10^{16} m

Therefore, 5.32 ly = $\frac{503314.56 \times 10^{11}}{3.08 \times 10^{16}}$ = 1.63 parsec

$\theta = \frac{d}{D}$

We know that, d = 3×10^{11} m

D = 503314.56×10^{11} m

$\theta = \frac{3 \times 10^{11}}{503314.56 \times 10^{11}} = 5.96 \times 10^{-6}$ rad

1 sec = 4.85×10^{-6}

5.96×10^{-6} rad = $\frac{5.96 \times 10^{-6}}{4.85 \times 10^{-6}} = 1.22^{\circ}$.

2.21 Precise measurements of physical quantities are a need for science. 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 actual motivation behind the discovery of radar in World War II. Think of different examples in modern science where precise measurements of length, time, mass etc. are needed. Also, wherever you can, give a quantitative idea of the precision needed.

Ans:

Precise measurement is essential for the development of science. The ultra-short laser pulse is used for measurement of time intervals. X-ray spectroscopy is used to find the interatomic separation. To measure the mass of atoms, the mass spectrometer is developed.

2.22 Just as precise measurements are necessary for 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) :
(a) the total mass of rain-bearing clouds over India during the Monsoon
(b) the mass of an elephant
(c) the wind speed during a storm
(d) the number of strands of hair on your head
(e) the number of air molecules in your classroom.

(a) During the monsoon, the total mass of rain clouds over India.
Ans.
The metrologist records 325 cm of rain, which is the height of the water column. h = 325 cm = 3.25 m
Area = 3.3×10^{12} m^2
Volume of water = A x h = $3.25 \times 3.3 \times 10^{12} = 10.725 \times 10^{12}$ m^3
Density of water = 1×10^3 kg m^{-3}
Therefore, the mass of rain water = $\rho \times V = 1 \times 10^3 \times 10.725 \times 10^{12} = 10.725 \times 10^{15}$ kg

Thus, the total mass of rain bearing clouds is 10.725×10^{15} kg

(b) An elephant's mass
Ans.
Let a known base area be floating in the sea. Let the depth of sea be d_1.
Volume of water displaced = A d_1
Now measure the depth of the ship with an elephant onboard.
Volume of water displaced = A d_2
From the above equations, the volume of water displaced by the elephant = A d_1 – A d_2
Water density = D
Elephant's mass = $AD(d_2 - d_1)$

(c) The speed of the wind in a storm.
Ans.
Anemometer is used to measure the speed of the wind. As the wind blows, it rotates the anemometer and the number of rotations per second gives the wind speed.

(d) The strands of hair in your head
Ans.

The surface area of the head = A
Let r be the radius

Area of one hair = πr^2

Number of strands of hair = $\frac{Total\ surface\ area}{area\ of\ one\ hair} = \frac{A}{r^2}$

(e) Air molecules in a room
Ans.
Let V be the volume of the room
In mole, the number of molecules = 6.023 x 10^{23}
One mole of air = 22.4 x 10^{-3} m^3 volume

Number of molecules in room = $\frac{6.023 \times 10^{23}}{22.4 \times 10^{-3}}$ = 134.915 x 10^{26} V

2.23 The Sun is a hot plasma (ionized matter) with its inner core at a temperature exceeding 107 K, and its outer surface at a temperature of about 6000 K. At these high temperatures, no substance remains in a solid or liquid phase. In what range do you expect the mass density of the Sun to be, in the range of densities of solids and liquids or gases? Check if your guess is correct from the following data: a mass of the Sun = 2.0 × 10^{30} kg, radius of the Sun = 7.0 × 10^8 m.
Ans:
Mass = 2 x 10^{30} kg
Radius = 7 x 10^8 m

Volume V = $\frac{4}{3}\pi r^3$

= $\frac{4}{3}$ x $\frac{22}{7}$ x $(7 \times 10^8)^3$

= $\frac{88}{21}$ x 512 x 10^{24} m^3 = 2145.52 x 10^{24} m^3

Density = $\frac{Mass}{Volume} = \frac{3 \times 10^{30}}{2145.52 \times 10^{24}}$ = 1.39 x 10^3 kg/m^5.

The density is in the range of solids and liquids. Its density is due to the high gravitational attraction on the outer layer by the inner layer of the sun.

2.24 When the planet Jupiter is at a distance of 824.7 million kilometres from the Earth, its angular diameter is measured to be 35.72″ of arc. Calculate the diameter of Jupiter.
Ans:

Distance D = 954.3 x 10^6 km = 954.3 x 10^9 m

Angular diameter = $38.23''$ = 38.23 x 4.874 x 10^{-6} rad

Jupiter's diameter = d

We know that, $\theta = \frac{d}{D}$

d = θD = 954.3 x 10^9 x 38.23 x 4.874 x 10^{-6}

= 177817.60 x 10^3

=1.778 x 10^5 Km.

radius r = $r_0 A^{\frac{1}{3}}$

R_0 = 1.2 f = 1.2 x 10^{-15} m

Volume of nucleus, V = $\frac{4}{3}\pi r^3$

= $\frac{4}{3}\pi(r_0 A^{\frac{1}{3}})^3$ = $\frac{4}{3}\pi r_o^3 A$

Nuclei mass M is equal to mass number

M = A x 1.66 x 10^{-27} kg

Density ρ = $\frac{nucleus\ mass}{nucleus\ volume}$

= $\frac{A \times 1.66 \times 10^{-27}}{\frac{4}{3}\pi r_0^3 A}$

= $\frac{3 \times 1.66 \times 10^{-27}}{4 \times \pi r_0^3}$ kg/m^3

The above relation shows that r_0 constant depends on nucleus mass. Thus, the mass density of all nuclei are almost same.

$\rho_{sodium} = \frac{3\times1.66\times10^{-27}}{4\times3.14\times(1.2\times10^{-15})^3}$

$= \frac{4.98\times10^{18}}{21.71} = 2.29 \times 10^{17}$ kg m^{-3}.