MEASUREMENT, UNITS AND DIMENSIONS

SIGNIFICANT FIGURES

1. **Significant figure**: Significant figures in a measurement are defined as the number of digits that are known reliably plus the uncertain digit

2. **Rules for determining the number of significant figures:**
   a) All the non-zero digits in a given number are significant without any regard to the location of the decimal point if any
   b) E.g.: 2405, 24.05, 2.405, 240.5 all have same number of significant digits i.e. 4.
   c) All zeros occurring between two non-zero digits are significant without any regard to the location of decimal point if any
   d) E.g.:1.006, 10.06,100.6 all have same number of significant figures i.e. 4.
   e) All the zeros to the right of the decimal point but to the left of the first non zero digit are not significant
   f) E.g.: 0.002 in these number significant digits are 1.
   g) All zeros to the right of the last non zero digit in a number after the decimal point are significant
   h) E.g.: 0.2300 has 4 significant figures
   i) All zeros to the right of the last non zero digit in a number having no decimal point are not significant
   j) E.g.: 2300 has 2 significant figures
   k) But if the zero after 3 in the number 2300 is obtained from an actual measurement, then the number of significant figures in 2300 be 4.

3. Rounding off:

1. The preceding digit is raised by one if the immediate insignificant digit to be dropped is more than 5

E.g.: When 2428 is rounded off to three significant figures, it becomes 2430

2. The preceding digit is to be left unchanged if the immediate insignificant digit to be dropped is less than 5

E.g.: If 2428 is rounded off to two significant figures it becomes 2400

3. If the immediate insignificant digit to be dropped is 5 then there will be two different cases

a) If the preceding digit is even, it is to be unchanged and 5 is dropped

E.g.: If 2.728 is to be rounded off to two decimal places, it becomes 2. 72

b) If the preceding digit is odd, it is to be raised by 1

E.g.: If 2.7358 is to be rounded off two decimal places it becomes 2.74

Rules for arithmetic operations with significant figures:

1. Addition and subtraction:

For addition and subtraction, the rule in terms of decimal places

i) After completing addition or subtraction, round off the final result to the least number of decimal places (n)

Eg 1) : Find the value of 2.2 + 8.08 + 3.125 + 6.3755

Ans: 15.78 is rounded off to 15.8
Eg (2): Find the value of 44.8 – 21.235
Ans: 23.56 is rounded off to 23.6
Finally Hence in addition or subtraction the final result should retain only that many decimal places as are three in the number with least decimal places

2. Multiplication and division: In multiplication and division, the rule is in terms of significant figures

i) In a given set of numbers, notice the number with the least number of significant figures (n) and the round off the other number to $(n+1)$ significant figures. Complete the arithmetic operation

ii) After completing multiplication or division round off the final result to the least number of significant figures (n)

E.g. (1): Find the value of $1.2\times2.54\times3.257$

$1.2\times2.54\times3.26=9.93468$

Final result is rounded off to 9.9

Eg : 2) Find $9.27\div41$

$\frac{9.27}{41}=0.2260975$

Final result is rounded off to 0.23

Hence in multiplication or division, the final result should retain only that may significant figures as there in the original number with the least number of significant figures.

SHORT ANSWER QUESTIONS

1. What is rounding off a number and what are the rules to be followed in it?

Ans. Rounding off Numbers:

The process of omitting the non significant digits are retaining only the desired number of significant digits, incorporating the required modifications to the last significant digit is called rounding off the number.

Rules for rounding off numbers

1.The Preceding digit is to be raised by 1, if the immediate digit to be dropped is more than 5.
Eg: 1.528 can be rounded off to the three significant figures as 1.53.

2.The preceding digit is to be left unchanged, if the immediate insignificant digit to be dropped is less than 5.
Ex: 1.52 can be rounded off to two significant figures as 1.5

3.If the immediate insignificant to be dropped is 5 then there will be two different cases.
(i) If the preceding digit is even, it is to be unchanged and 5 is dropped.
Eg: 1.65 can be rounded off as 1.6
(ii) If the preceding digit is odd, it is to be raised by one
Eg: 1.35 can be rounded off as 1.4

2. What are the rules for arithmetic operations with significant figures

Ans. <u>Rules for arithmetic operations with significant figures:</u>

To obtain the result many physical quantities are have to make arithmetic operations (addition, subtraction, multiplication, division etc) of the measured quantities.
The final result of arithmetic operations should never have more significant figures than the least number of significant figures in the original components.

1. Addition and subtraction:

For addition and subtraction, the rule is in terms of decimal places.
(i) In a given set of numbers, notice the number with least number of decimal places (n) and then round off all other numbers to (n+1) decimal places. Complete the arithmetic operation.

(ii) After completing addition (or) subtraction, round off the final result to the least number of decimal places (n)
Eg: Find the Value of 2.2 + 4.08 + 3.125 + 6.3755.
Out of the given values 2.2 has only one decimal place, hence rounding off all other the numbers to the decimal places. Hence 4.08 retains as it is 3.125 is to be rounded off as 3.12 (as 2 before 5 is even). 6.3755 is to be rounded off as 6.38 (as 7 before 5 is odd). Now adding
2.2 + 4.08 + 3.12 + 6.38=15.78.
Finally we should have only one decimal place and hence 15.78 is to be rounded off as 15.8.

2. Multiplication and division

In multiplication and division, the rule is in terms of significant figures.
(i) In a given set of numbers, notice the number with least number of significant figures(n) and then round off all other numbers to (n+1) significant figures. Complete the arithmetic operation.
(ii) After completing multiplication or division round off the final result to the least number of significant figures (n)
Eg: Find the product of 1.2, 2.54 and 3.257.
<u>Sol:</u> Out of three numbers 1.2 has got the least number of significant figures ie 2. Now, we should round off the other number to 3 significant figures 2.54 has 3 significant figure hence it remains as it is 3.257 is to be rounded off as 3.26

$$= 1.2 \times 2.54 \times 3.26$$
$$= 9.93648$$

But the result should be limited to the least number of significant figures-that is two digits only
The final result should be written as 9.9 after rounding off

3. What is meant by significant figures? How are these counted?

Ans. <u>Significant figures:</u>

Generally all the digits in a number (measurement) are not reliable. In a measurement we can write the reliable value plus one estimated value.
"The digits of a number that are definitely k nown plus one more digit that is an estimated are called significant digits (or) significant figures."

Rules for determining the number of Significant figures

1. All the non-zero digits in a given number are significant without any regard to the location of the decimal point if any
Eg:18452 or 1845.2 or 184.52 or 18.452 or 1.8452 all have the same number of significant figures. ie Five

2. All zeros occurring between two non-zero digits are significant without any regard to the location of decimal point if any
Eg: 106008, 106.008, 1.06008 all have same number of significant figures i. e six.
3. If the number is less than one, all the zeros to the right of the decimal point but to the left of the first non-zero digit are not significant
Eg: 0.0306 has only 3 significant figures.

4. All the zeros to the right of last non zero digit in a number, after the decimal point are significant
Eg: 30.00 has four significant figures.

5. All zeroes to the right of the last non-zero digit on a number having no decimal point are not significant.
Eg: 2020 has only three significant figures
But if the zero, after 2 in the number 2020 is obtained from an actual measurement, then the number of significant figures in 2020 as 4, it can be written as 2.020×10^3.

4. Round off to 3 significant figures giving the rules followed
i) 25.87 ii) 0.05134 iii) 25.87

Ans. It has four significant numbers. Since the insignificant digit to be dropped is 7 which is greater than 5, the preceding digit is to be raised by 1
Answer is 25.9
ii) 0.05134
It has four significant numbers. Since the insignificant digit to be dropped is 4, which is less than 5, the preceding digit is to be left unchanged.
Answer is 0.0513

VERY SHORT ANSWER QUESTIONS

1. Are all the significant figures reliable?

Ans. No. significant figures are the digits of a number that are definitely known plus one more digit that is estimated. So last digit is not reliable.
Ex. If the length of an object is 5.26, the significant figures are 5,2 and 6. The last digit 6 is not reliable.

2. What is rounding off a number?

Ans. The process of omitting non-significant figures and retaining only the desired number of significant figures is called rounding off a number.

3. What are significant figures? Give an example.

Ans. The digits of a number representing a measurement that are definitely know plus one more digit that is estimated are called significant figures.
Ex. If the length of an object is 5.26, the significant figures are 5,2 and 6 is uncertain digit. But all the three are significant.

Exercise 1

1. Find the product of 1.2, 2.54 and 3.257 with due regard to significant figures.

A. Among the three numbers 1.2 has least number of significant figures i.e. two. So other numbers should be rounded off to 2+1=3 significant figures and carry out the multiplication. 2.54 has three significant figures and hence needs no rounding off. 3.257 is to be rounded off to 3.26.
1.2×2.55×3.26 = 9.93648. But the result should be limited to the least number of significant digits – that is two digits only.
Answer 9.9

2. Find the value of $\frac{\pi}{53.2}$ with due regard to significant figures.

A. Out of the two numbers 53.2 has three significant digits. So, π should be written with 3+1=4 significant figures.
$\pi = 3.1415 = 3.142$ (As 1 is odd it is raised by one)
Now $\frac{3.142}{53.2} = 0.0590601$
This is to be rounded off to three significant figures.
0.059060 = 0.0591

3. Find the value of 2.2+4.08+3.125+6.3755.

A. Among the four numbers 2.2 has got the least number of decimal places i.e. one.
Hence we should retain only two decimal places in the remaining numbers. Hence 4.08 remains as it is 3.125 is to be rounded off as 3.12 (as 2 before 5 is ever) 6.3755 is to be rounded off as 6.38 (as 7 before 5 is odd). Now adding 2.2+4.08+3.12+6.38=15.78.
Finally we should haves only one decimal place and hence 15.78 is to be rounded off as 15.8.

4. Find the value of 44.8 – 21.235.

A. Only one decimal places is there in 44.8. Hence the other number is to be rounded off to have two decimal places. 21.23$\underline{5}$ – 21.24 (as 3 before 5 is odd). Now 44.8 – 21. 24 = 23.56. Finally this is to be rounded off to one decimal place as 23.6.

5. Write down the number of significant figures in the following.

i) 0.007 ii) 2.64×10^{24} iii) 0.2370 iv) 6.320

v) 6.032 vi) 0.0006032

A. i) 0.007 has one significant figure.

ii) 2.64×10^{24} has three significant figures.

iii) 0.2370 has four significant figures.

iv) 6.320 has four significant figures.

v) 6.032 has four significant figures.

vi) 0.0006032 has four significant figures.

6. Round off to 3 significant figures:

i) 20.96 ii) 0.0003125

A. i) 20.96 has four significant figures. The fourth significant figure has more than 5 and hence on rounding off to three significant figures, the given measurement will becomes 20.9+0.1 i.e. 21.0.

ii) 0.0003125 has four significant figures. The fourth significant figure is 5 and hence on rounding off to three significant figures, the given measurement will become 0.000312 or 3.12×10^{-4}. This is because 2 before 5 is an even number.

7. Find out the results of the following operations.

i) 117.3×0.0024 ii) $9.27 \div 41$

iii) 42×0.041 iv) $124.2+52.487$

v) $124.2 - 52.487$ vi) $\sqrt{58.97}$ vii) $(17.5)^2$

A. i) 0.0024 has 2 significant figures. Hence 117.3 is rounded off to have 2+1=3 significant figures. It becomes 117 only.

Now $117\times0.0024 = 0.2808$.

This is to be rounded off to have two significant figures only. The result is 0.28.

ii) 41 has only 2 significant digits. Hence 9.27 can have 2+1=3 significant digits. It has 3 significant digits only. No need of rounding off.

$\frac{9.27}{41} = 0.2260975$. This is to be rounded off to two significant digits. The results is 0.23.

iii) Both numbers have two significant digits. $42\times0.041 = 1.722$. This is to be rounded off to 2 significant digits. The results is 1.7.

iv) As this is a sum, we have to consider decimal places. 124.2 has only one decimal place. Hence 52.487 is to be rounded off to 1+1=2 decimal places.

It becomes as 52.48$\underline{7}$ = 52.49.

Now 124.2+52.49 = 176.69. This is to be rounded off to one decimal place. The result is as 176.69 = 176.7.

v) 124.2 – 52.48$\underline{7}$ = 124.2 – 52.49 = 71.71. This is to be rounded off to one decimal place.

vi) $\sqrt{58.97} = 7.679$. Number of significant digits is 4 in both. But for square roots its is customary to have the number of significant figures one less than the number that is, 7.68.

vii) $(17.5)^2$ = 306.28. The original number 17.5 has only 3 significant digits. And hence the result will be 306.

Exercise 2

1. Find the number of significant figure in the following numbers.
i) 6729, ii) 0.024, iii) 6.0023, iv) 2.520×10^7 , v) 0.08240, vi) 4200, vii) 4.57×10^8 , viii) 91.000.

Sol. i) 6729 $\rightarrow$ 4 ii) 0.024 $\rightarrow$ 2. iii) 6.0023 $\rightarrow$ 5 iv) $2.520\times10^7 \rightarrow 4$.
v) 0.08240 $\rightarrow$ 4 vi) 4200 $\rightarrow$ 2. vii) $4.57\times10^8 \rightarrow 3$ viii) 91.000 $\rightarrow$ 5.

2. Solve with due regard to significant figures. a) 46.7 – 10.04. …….
b) $(3.0\times10^{-8}) + (4.5\times10^{-6})$ = …….

Sol. a) 46.7 is written as 46.7 and 10.04 is written as 10.0
46.7 – 10.0 = 36.7
b) 3.0×10^{-8} written as same since it has no. of significant figures less i.e. 2.
4.5×10^{-6} is written as 450×10^{-8} so that the power is same and same number of significant figures.
$\therefore \left(3.0\times10^{-8}\right)+\left(45010^{-8}\right) = 453.0\times10^{-8} = 4.5\times10^{-6}$
(Rounded off to 2 significant figures).

3. A stick has a length of 12.132 cm and another stick a length of 12.4 cm.
a) If the two sticks are placed end to end, what is their total length?
b) If the two sticks are placed side by side, what is the different in their lengths?

Sol. Length of 1st stick = 12.132 cm = 12.1 cm
a) Total length = 12.1+12.4 = 24.5 cm
b) Different in lengths = 12.4 – 12.1 = 0.3 cm

4. The mass of 1.2 cm^3 of a certain substance is 5.74g. Calculate its density with due regard to significant figures.

Sol. Volume = V = 1.2 cm^3 (2 significant figures)
Mass = m = 5.74 gm = 5.7 gm (Rounded off to 2 significant figures)
$\therefore \text{Density} = d = \frac{m}{V} = \frac{5.7}{1.2} = \frac{57}{12} = 4.75 = 4.8 \text{gm cm}^{-3}$
(Rounded off to 2 significant figures)

5. If a circular piece of tin has a measured radius of 2.6 cm.What is its circumference?

Sol. Radius = r = 2.6 cm (2 significant figures)

π = 3.14 = 3.1 (rounded of to 2 significant figures)

Circumference = $2\pi r = 2\times 3.1\times 2.6$ = 16.12 cm = 16

(Rounded off to 2 significant figures)

6. The diameter of a sphere is 4.24 cm. Calculate its surface area with regard to significant figures.

Sol. Diameter = 4.24 cm

$$\text{Radius} = \frac{1}{2}(\text{Diameter}) = \frac{1}{2}(4.24)$$

$\therefore$ R = 2.12 m (3 significant figures)

$\pi = 3.14$ (3 significant figures)

$A = 4\pi R^2 = 4\times 3.14\times 2.12\times 2.12 = 56.449664 = 56.4\text{m}^2$. (3 significant figures)

7. Each side of a cube is measured to be 7.203 m. What (i) the total surface area and (ii) the volume of the cube to appropriate significant figures?

Sol: a = 7.203 m

Total surface area = $6a^2 = 6\times 7.203\times 7.203$ = 311 .29 9254

$\therefore$ Total surface area = 311.3m^2 (rounded off to 4 significant figures)

Volume of cube = $a^3 = 7.203\times 7.203\times 7.203$ = 373.614754427

$\therefore$ V = 373 .6 m^3 (Rounded off to 4 significant figures)

8. Find the value of the following addition with due consideration of significant figures 0.75+2.128+15.6

Sol: 0.75 is written as 0.750 (3 significant figures)

2.128 is written as 2.13 (Rounded to 3 significant figures)

15.6 is written as 15.6 (3 significant figures)

$\therefore$ 0.750 +2.13 + 15.6 = 18.480=18.5

(Rounded off to 3 significant figures)

9. Find the value of 31.2 – 12.125 with due consideration of significant figures.

Sol: 31.2 is written as 31.2 (3 significant figures)

12.125 is written as 12.1 (3 significant figures)

$\therefore$ 31.2 – 12.1 = 19.1 (3 significant figures)

10. The length of a rod is 2.5 cm and diameter is 2.5 mm. Find the volume of the rod with due consideration to significant figures.

Sol: Length of rod = l = 2.5 cm (2 significant figures)

Diameter = 2.5 mm = 0.25 cm

Radius = r = $\frac{0.25}{2} = 0.125cm$ = 0.12 cm = 0.12 cc.