Units and Measurements

Significant Figures

Rules for Determining Significant Figures

Definition:
Significant figures (or significant digits) in a measurement include all the digits that are known with certainty plus the first uncertain digit. They are important because they indicate the precision of a measurement.

Rules:

1. **Non-zero digits**: All non-zero digits are significant.

   - Example: 123.45 has five significant figures.

2. **Zeros between non-zero digits**: Zeros between non-zero digits are significant.

   - Example: 1002 has four significant figures.

3. **Leading zeros**: Zeros to the left of the first non-zero digit are not significant.

   - Example: 0.0025 has two significant figures.

4. **Trailing zeros in a decimal number**: Zeros to the right of a decimal point and following a non-zero digit are significant.

   - Example: 2.300 has four significant figures.

5. **Trailing zeros in a whole number with a decimal point**: Trailing zeros in a whole number with a decimal point are significant.

   - Example: 150.0 has four significant figures.

6. **Exact numbers**: Numbers that are definitions or countable quantities have an infinite number of significant figures.

   - Example: 1 meter = 100 centimeters (exactly).

Rounding Off

Definition:
Rounding off is the process of reducing the number of significant figures in a number while maintaining its value as close to the original as possible.

Rules:

1. **If the digit to be removed is less than 5**, the preceding digit remains unchanged.

    - Example: 2.343 rounded to three significant figures is 2.34.

2. **If the digit to be removed is 5 or greater**, the preceding digit is increased by 1.

    - Example: 2.346 rounded to three significant figures is 2.35.

3. **When rounding off a number ending with 5**, if the preceding digit is even, it remains unchanged; if it is odd, it is increased by 1.

    - Example: 2.35 rounded to two significant figures is 2.4 (since 3 is odd).
    - Example: 2.45 rounded to two significant figures is 2.4 (since 4 is even).

Arithmetic Operations with Significant Figures

Addition and Subtraction:
When performing addition or subtraction, the result should have the same number of decimal places as the measurement with the least number of decimal places.

- **Example**:

$$12.11 + 18.0 + 1.013 = 31.123 \text{ (before rounding)}$$

$$31.123 \rightarrow 31.1 \text{ (after rounding to one decimal place)}$$

Multiplication and Division:
When performing multiplication or division, the result should have the same number of significant figures as the measurement with the least number of significant figures.

- **Example**:

$$4.56 \times 1.4 = 6.384 \text{ (before rounding)}$$

$$6.384 \rightarrow 6.4 \text{ (after rounding to two significant figures)}$$

Combined Operations:
For combined operations, follow the rules for significant figures at each step of the calculation.

- **Example**:

$$(2.5 + 3.42) \times 2.1 = 5.92 \times 2.1 = 12.432 \text{ (before rounding)}$$

$$5.9 \times 2.1 = 12.4 \text{ (after rounding to two significant figures)}$$

Tips:

- Perform all steps of the calculation first before rounding off to the appropriate number of significant figures.
- Keep track of significant figures at each step to ensure accuracy in the final result.

Understanding and applying the rules for significant figures, rounding off, and arithmetic operations ensure the precision and accuracy of measurements and calculations in scientific work.