Uncertainty in Measurement

Aim

- to calculate quantities with the correct number of significant figures using actual measurements

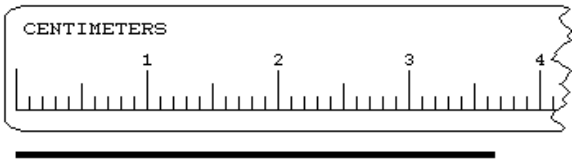
Notes

Degree of certainty determined by two factors

- ★ Precision - reliability or reproducibility of a measurement
- ★ Accuracy - closeness to the known or accepted value

Significant figures

- ★ Nature of significant figures
  - ☆ the number of figures that are certain in a measurement are limited by the smallest interval of the measuring device
  - ☆ it is possible to estimate one additional decimal place beyond the figures that are certain
  - ☆ the last decimal place is always considered an estimate
  - ☆ the number of significant figures in a number is the number of figures that are certain plus the one that is estimated



The line is between 3.6 and 3.7 cm. The actual length is closer to 3.65 cm. The last digit is estimated. There are three significant figures.

- ★ Calculations with significant figures
  - ☆ multiplication and division - the number of significant figures in a product or quotient is the same as the measurement with the smaller number of significant figures

Problem
3.1415 × 2.25 = 7.068375

Correct number of Significant Figures = 3

Solution
7.07

  - ☆ addition and subtraction - the number of decimal places in the sum or difference is equal to the number of decimal places in the measured quantity with the smallest number of decimal places

Problem
6.357 - 2.4 = 3.957
Correct number of Decimal Places = 1

Solution
4.0

  - ☆ place holder zeros are ***NOT*** significant
    - ★ 0.015 m has 2 significant figures as does the equivalent 15 cm
    - ★ 0.0150 m has 3 significant figures as does the equivalent 15.0 cm

Error analysis

- **Observed value** - value based on laboratory measurements
- **True value** - most probable value or accepted value based on references
- Absolute error = |Observed value – True value|
- $Percent\ error = \frac{|observed\ value - true\ value|}{true\ value} \times 100\%$

Answer the questions below by circling the number of the correct response

1. According to an accepted chemistry reference. the heat of vaporization of water is 540. calories per gram. A student determined in the laboratory that the heat of vaporization of water was 620. calories per gram. The student's results had a percent error of (1) 12.9, (2) 80.0, (3) 14.8, (4) 87.1

2. Which measurement contains a total of three significant figures? (1) 0.01 g (2) 0.0100 g (3) 0.010 g (4) 0.01000 g

3. In an experiment the gram atomic mass of magnesium was determined to be 24.7. Compared to the accepted value 24.3, the percent error for this determination was (1) 0. 400, (2) 24.7, (3) 1.65, (4) 98.4

4. A student determined the melting point of a substance to be 55.2°C. If the accepted value is 50. 1°C the percent error in her determination is (1) 5.10, (2) 10.2, (3) 9.24, (4) 12.0

5. Using the rules for significant figures, the sum of 0. 027 gram and 0. 0023 gram should be expressed as (1) 0. 029 gram, (2) 0.03 gram, (3) 0.0293 gram, (4) 0.030 gram

6. Which milligram quantity contains a total of four significant figures? (1) 0.3010 mg (2) 3100 mg (2) 3010 mg (4) 30001 mg

7. In an experiment, a student found that the percent of oxygen in a sample of $KClO_3$ was 42.3%. If the accepted value is 39.3%, the experimental percent error is

(1) $\frac{42.3}{39.3} \times 100\%$ (3) $\frac{3.0}{42.3} \times 100\%$

(2) $\frac{39.3}{42.3} \times 100\%$ (4) $\frac{3.0}{39.3} \times 100\%$

8. A student has to measure the diameter of a test tube in order to calculate the tube's volume. Based on the diagram at the right, the tube's diameter is closest to
(1) 1.25 cm
(2) 2.32 cm
(3) 3.25 cm
(4) 12.5 cm