Nature of Measurement

Measurement - quantitative observation consisting of 2 parts

Part 1 - number

Part 2 - scale (unit)

Examples:

20 grams

6.63×10^{-34} Joule seconds

International System (SI)

Based on metric system and units derived from metric system.

The Fundamental SI Units

Physical Quantity	Name	Abbreviation
Mass	kilogram	kg
Length	meter	m
Time	second	s
Temperature	Kelvin	K
Electric Current	Ampere	A
Amount of Substance	mole	mol
Luminous Intensity	candela	cd

SI prefixes

Prefix	Symbol	Multiplier	Exponential notation
exa-	E	1,000,000,000,000,000,000	10^{18}
peta-	P	1,000,000,000,000,000	10^{15}
tera-	T	1,000,000,000,000	10^{12}
giga-	G	1,000,000,000	10^{9}
mega-	M	1,000,000	10^{6}
kilo-	k	1,000	10^{3}
hecto-	h	100	10^{2}
deca-	da	10	10^{1}
deci-	d	0.1	10^{-1}
centi-	c	0.01	10^{-2}
milli-	m	0.001	10^{-3}
micro-	µ	0.000 001	10^{-6}
nano-	n	0.000 000 001	10^{-9}
pico-	p	0.000 000 000 001	10^{-12}
femto-	f	0.000 000 000 000 001	10^{-15}
atto-	a	0.000 000 000 000 000 001	10^{-18}

Uncertainty in Measurement

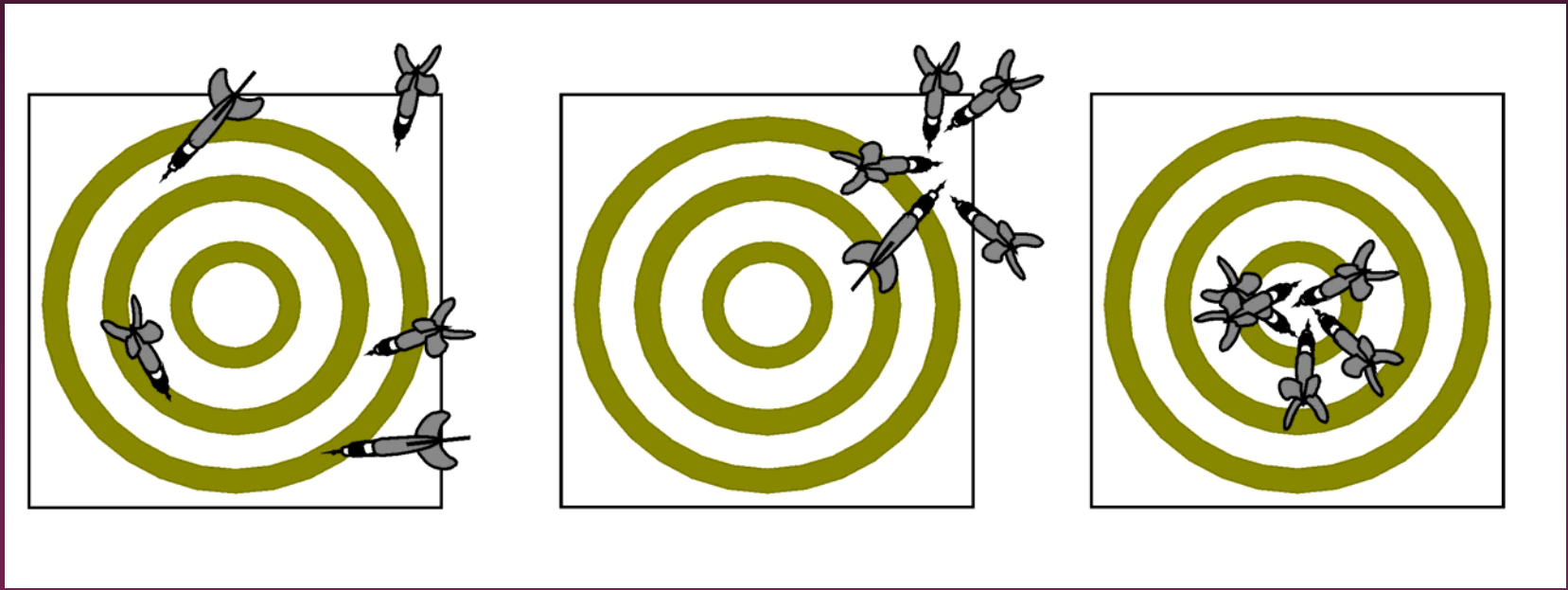
A digit that must be estimated is called uncertain. A measurement always has some degree of uncertainty.

Precision and Accuracy

Accuracy refers to the agreement of a particular value with the true value.

Precision refers to the degree of agreement among several elements of the same quantity.

Precision and Accuracy



Neither precize nor accurate Precize but not accurate Both precize and accurate

Types of Error

Random Error (Indeterminate Error) - measurement has an equal probability of being high or low.

Systematic Error (Determinate Error) - Occurs in the same direction each time (high or low), often resulting from poor technique.

Rules for Counting Significant Figures - Overview

1. Nonzero integers
2. Zeros
   - leading zeros
   - captive zeros
   - trailing zeros
3. Exact numbers

Rules for Counting Significant Figures - Details

Nonzero integers always count as significant figures.

3456 has

4 sig figs.

Rules for Counting Significant Figures - Details

Zeros

- Leading zeros do not count as significant figures.

0.0486 has

3 sig figs.

Rules for Counting Significant Figures - Details

Zeros

- Captive zeros always count as significant figures.

16.07 has

4 sig figs.

Rules for Counting Significant Figures - Details

Zeros

- Trailing zeros are significant only if the number contains a decimal point.

9.300 has

4 sig figs.

Rules for Counting Significant Figures - Details

Exact numbers have an infinite number of significant figures.

1 inch = 2.54 cm, exactly

Rules for Significant Figures in Mathematical Operations

Multiplication and Division: # sig figs in the result equals the number in the least precise measurement used in the calculation.

$$6.38 \times 2.0 =$$

$$12.76 \rightarrow 13 \text{ (2 sig figs)}$$

Rules for Significant Figures in Mathematical Operations

Addition and Subtraction: # sig figs in the result equals the number of decimal places in the least precise measurement.

$$6.8 + 11.934 =$$

$$22.4896 \rightarrow 22.5 \text{ (3 sig figs)}$$

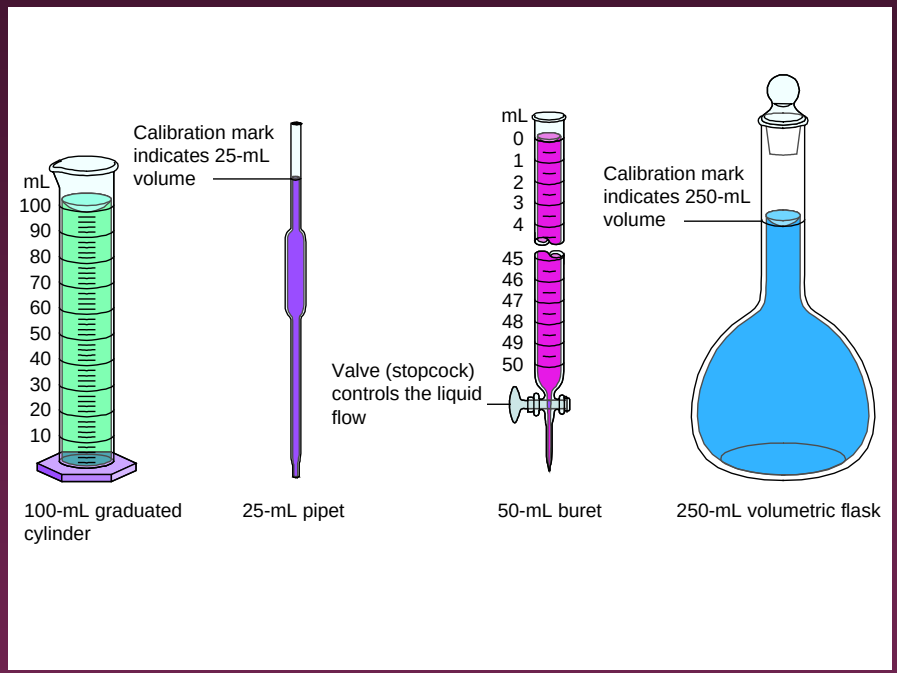
Dimensional Analysis

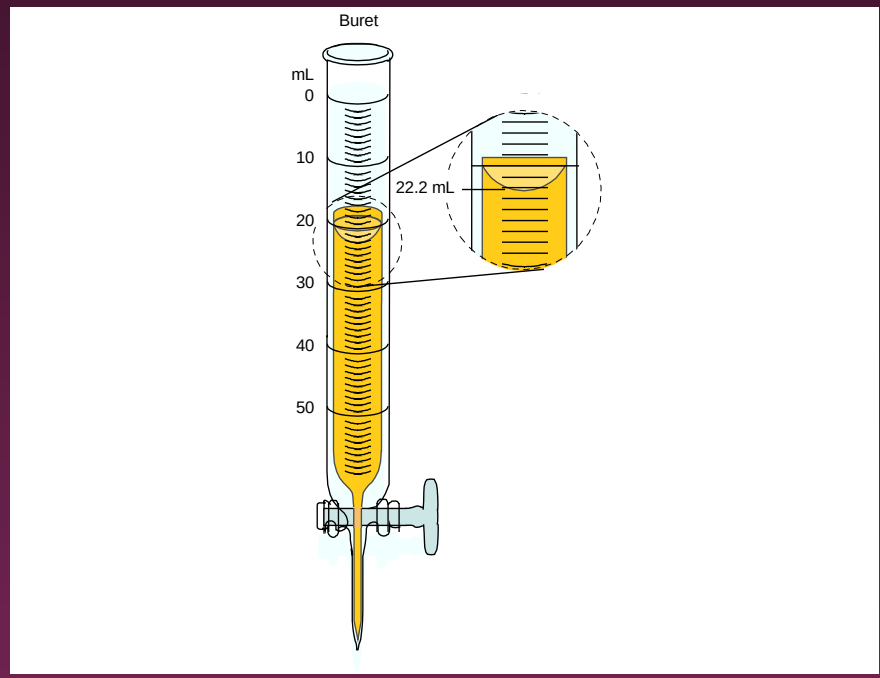
Proper use of “unit factors” leads to proper units in your answer.

OK: $\dfrac{1\ \text{kilometer}}{0.62137\ \text{mile}} = \dfrac{0.62137\ \text{mile}}{1\ \text{kilometer}}$

NOT OK: $\dfrac{1\ \text{kilometer}}{0.62137\ \text{mile}} = \dfrac{1\ \text{mile}}{0.62137\ \text{kilometer}}$

Volume





Read volume at the bottom of the liquid curve

Temperature

Celsius scale = °C

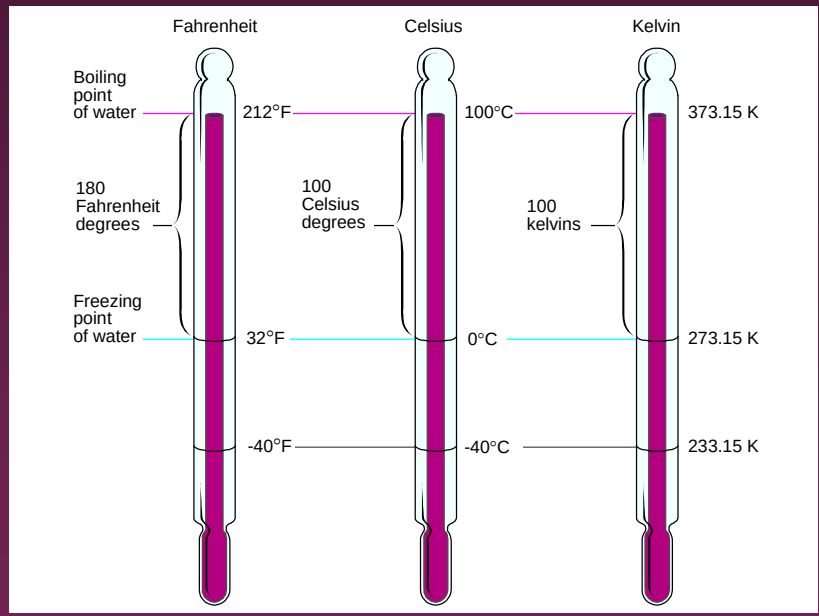
Kelvin scale = K

Fahrenheit scale = °F

Temperature

$$T_K = T_C + 273.15$$

$$T_F = T_C \times \frac{9°F}{5°C} + 32°F$$



Density

Density is the mass of substance per unit volume of the substance:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$