Measurement

International System of Units (SI)

- revised metric system proposed in 1960
- widely used in science
- 7 base units

SI Base Units

Length	Meter	m
Mass	Kilogram	kg
Time	Second	s or sec
Electrical current	Ampere	A or amp
Temperature	Kelvin	K
Amount of Substance	Mole	mol
Luminous intensity	Candela	cd

SI Prefixes

Tera-	T	10^{12}	Deci-	d	10^{-1}
Giga-	G	10^{9}	Centi-	c	10^{-2}
Mega-	M	10^{6}	Milli-	m	10^{-3}
Kilo-	k	10^{3}	Micro-	μ	10^{-6}
			Nano-	n	10^{-9}
			Pico-	p	10^{-12}

Derived units in SI

measured in terms of one or more base units

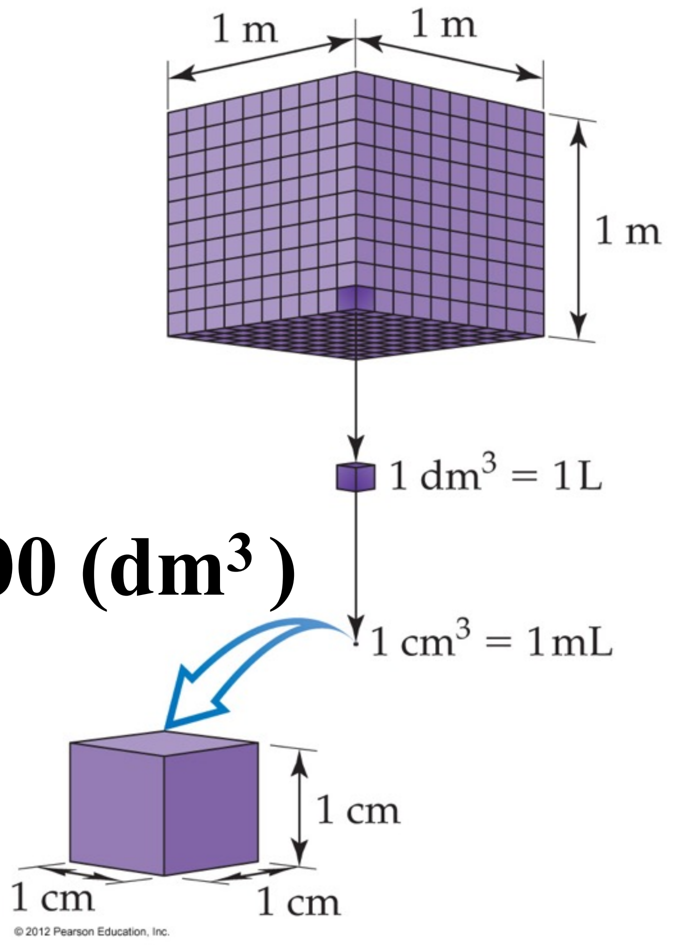
Volume

- The most commonly used metric units for volume are the liter (L) and the milliliter (mL).

volume

$$m \times m \times m = (m^3) = 1000\ (dm^3)$$

$1dm^3 = 1$ liter (L)



Density

The mass of a substance that occupies one unit of volume

$$\textbf{Density} = \frac{\text{mass}}{\text{volume}} = \frac{\text{g}}{\text{cm}^3} = \text{g/cm}^3$$

Example

What is the density of a piece of concrete that has a mass of 8.76 g and a volume of 3.07 cm³

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{8.76\text{g}}{3.07\ \text{cm}^3} = 2.85\text{g/cm}^3$$

Temperature

There are three systems for measuring temperature that are widely used:

Kelvin scale $K = C^{\circ} + 273.15$

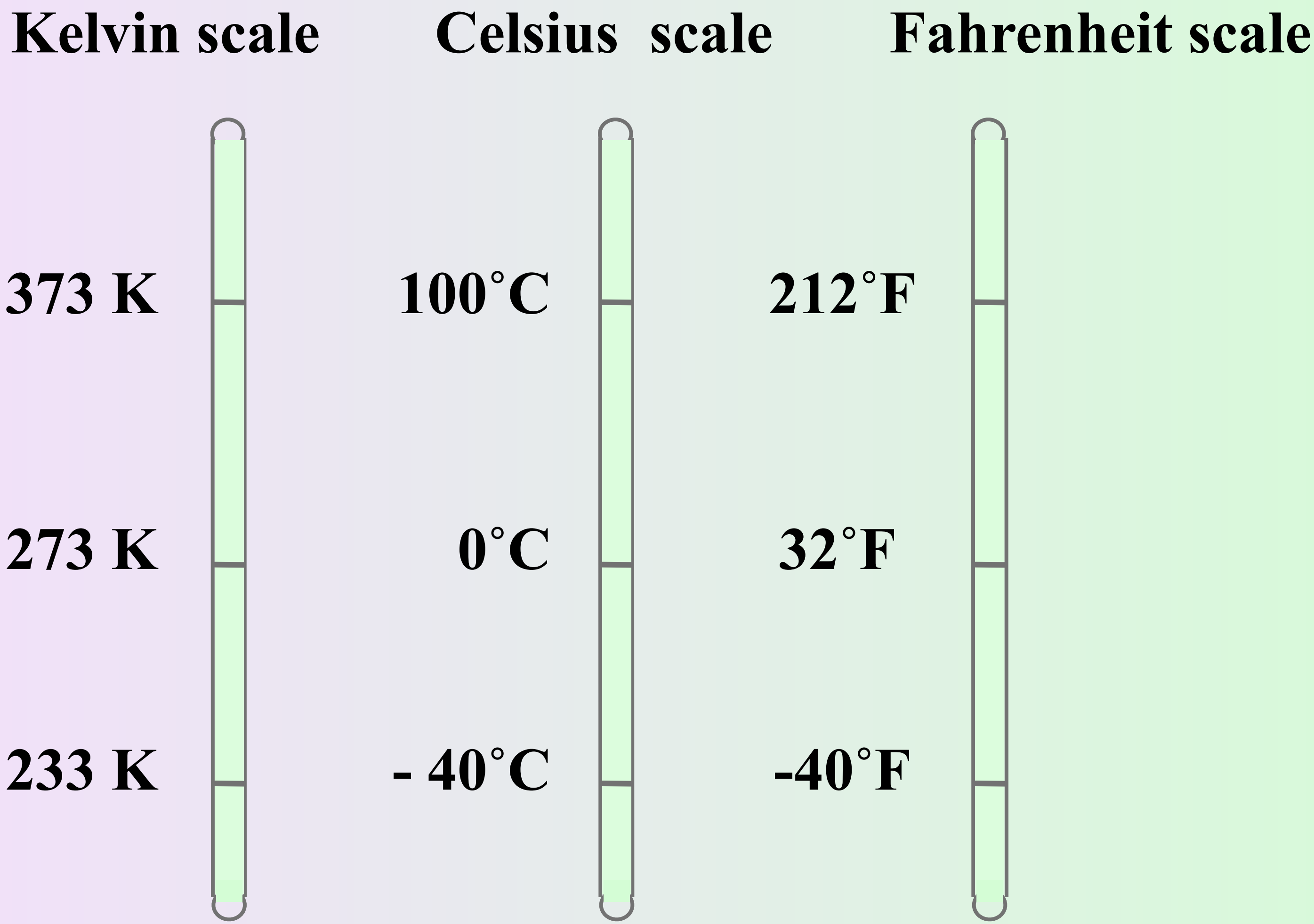
Celsius scale $C^{\circ} = K - 273.15$

Fahrenheit scale $F^{\circ} = C^{\circ}\,(9/5) + 32$

Used mainly in engineering

$C^{\circ} = (F^{\circ} - 32)\,5/9$

Temperature



Handling Numbers

In chemistry we deal with very large and very small numbers

Scientific Notation

is a way of dealing with numbers that are either extremely large or extremely small

$N \times 10^n$

where **N** is a number between 1 and 10 and **n** is an exponent that can be a positive or negative integer

Example

Express 568.762 in scientific notation.

$568.762 = 5.68762 \times 10^2$

note that the decimal point moved to the left by two places and n = 2.

Example

Express 0.00000772 in scientific notation.

$0.00000772 = 7.72 \times 10^{-6}$

note that the decimal point moved to the right by six places and $n = -6$.

practice problem

Express the following quantities in scientific notation.

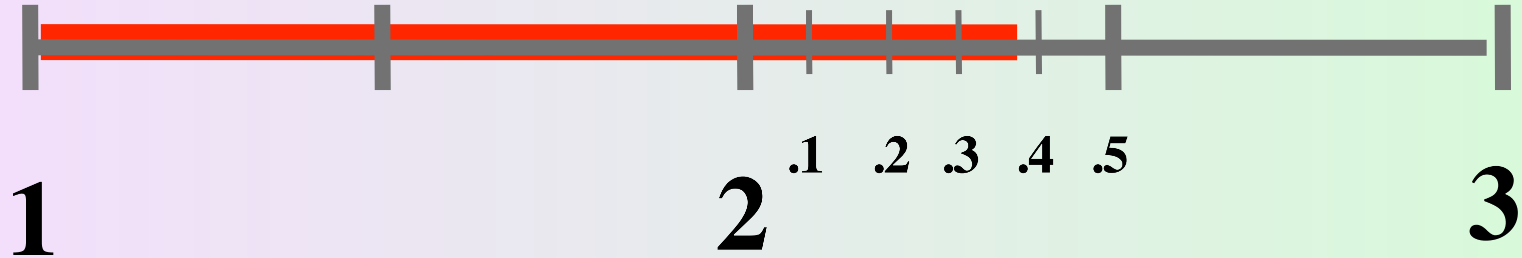
c. 4500000. m $= 4.5 \times 10^6$

practice problem

Express the following quantities in scientific notation.

f. 0.00000687 kg = **6.87×10^{-6}**

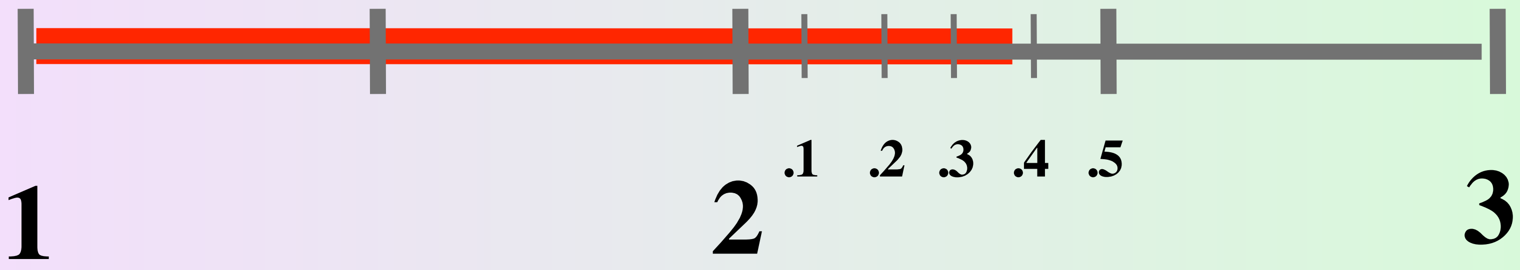
Uncertainty in measurement



2.36mm **2.37mm**

middle value ?

Uncertainty in measurement



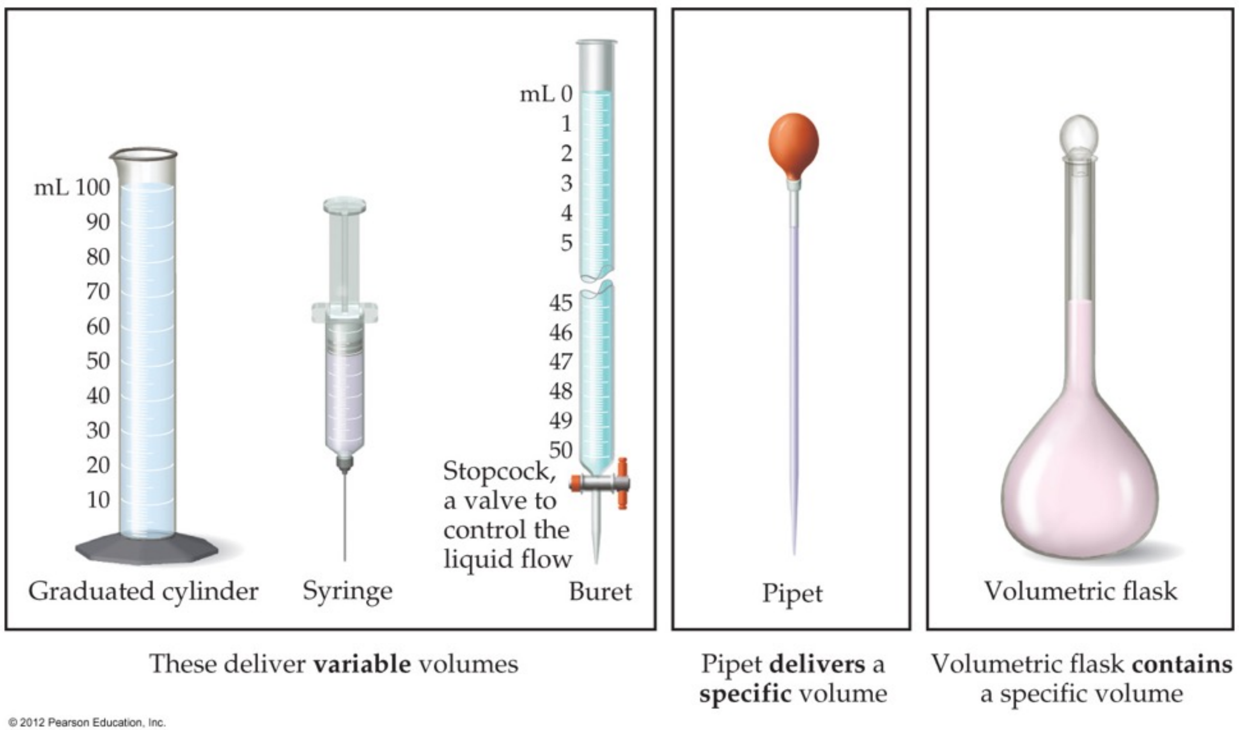
2.36mm **2.37mm**

middle value ?

There is uncertainty with this degree of accuracy

Uncertainty in Measurements

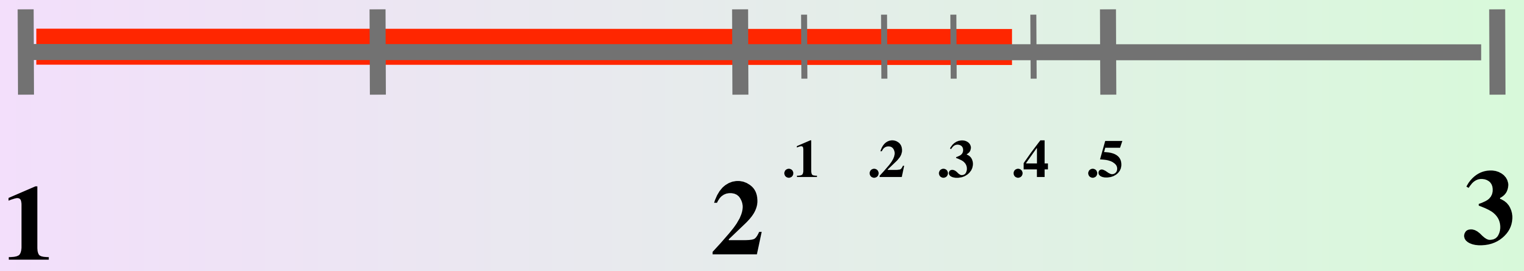
Different measuring devices have different uses and different degrees of accuracy.



Accuracy versus Precision

- **Accuracy** refers to the proximity of a measurement to the true value of a quantity.
- **Precision** refers to the proximity of several measurements to each other.

Uncertainty in measurement



2.37mm

The first two measured numbers are called *certain* digits

The the digit to the right of the 3 is called an *uncertain* digit

a measurement always has some degree of *uncertainty*

We customarily report a measurement by recording all the certain digits plus the first uncertain digit.

these numbers are called significant figures

Significant Figures

- The term **significant figures** refers to digits that were measured.
- When rounding calculated numbers, we pay attention to significant figures so we do not overstate the accuracy of our answers.

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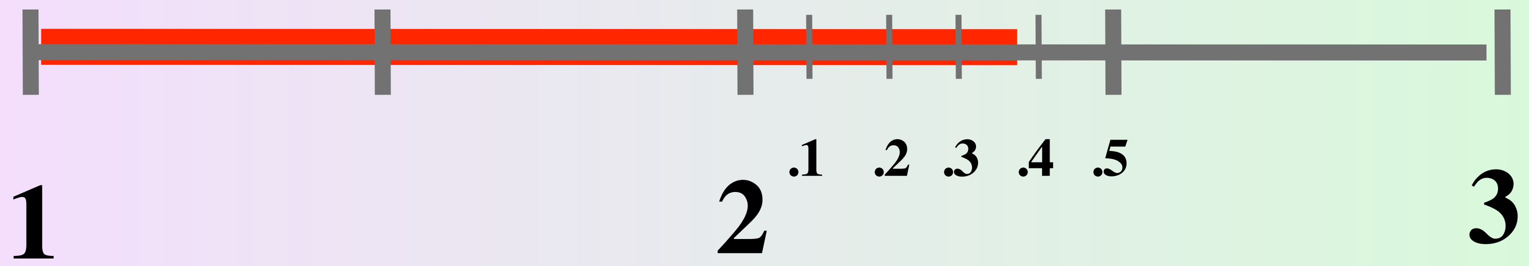

2.37mm

three significant figures in this measurement

Rules for Significant Figures

1. digits other than zero are always significant

67.8 g	**3 significant figures**
98. g	**2 significant figures**

2. one or more final zeros used after the decimal point are always significant

4.700 m	**4 significant figures**
82.0 m	**3 significant figures**

Rules for Significant Figures

3. zeros between two other significant digits are always significant

5.029 cm **4 significant figures**

4. zeros used solely for spacing the decimal point are not significant

0.00783 ml **3 significant figures**

0.34 g/ml **2 significant figures**

Rules for Significant Figures

If the zeros follow nonzero digits,there is ambiguity if no decimal point is given

300 N	**significant figures ?**
300. N	**3 significant figures**
300.0 N	**4 significant figures**

Avoid ambiguity by expressing measurements in scientific notation

3.0×10^2 N	**2 significant figures**

Significant Figures

- When addition or subtraction is performed, answers are rounded to the least significant **decimal place***.*

- When multiplication or division is performed, answers are rounded to the number of digits that corresponds to the ***least*** **number of significant figures** in any of the numbers used in the calculation.

Adding Significant Figures in Calculations

A result can only be as accurate as the least significant measurement

4.37 g

+ 1.002 g

5.372 g **3 significant figures**

Multiplying Significant Figures in Calculations

A result can only be as accurate as the least significant measurement

Volume = l x w x h = (1.87cm)(1.413cm)(1.207cm)

= 3.19cm^3

3 significant figures

Using Significant Figures in Calculations

A result can only be as accurate as the least significant measurement

21.mm - 13.8mm = 7.mm

1 significant figures

Rounding Off Rules

In a series of calculations, carry the extra digits through the final result, then round.

If the digit following the last reportable digit is:

- **4 or less, you drop it** — **1.33 to 1.3**

- **5 or more, you increase the last reportable digit by one** — **1.36 to 1.4**

Percent Error

Observed value

the value based on laboratory measurements

True value

the value based on accepted references

Absolute error

the difference between the observed value and the true value

(observed value - true value)

Percent Error

$$\%\ \text{Error} = \frac{\text{absolute error}}{\text{true value}} \times 100\%$$

Example

the boiling point of methanol is 65°C. Your measured boiling point of methanol is 66.0°C.what is the percent error in your measurement.

$$\% \text{ Error} = \frac{\text{absolute error}}{\text{true value}} \times 100\%$$

$$\% \text{ Error} = \frac{66^\circ C - 65^\circ C}{65^\circ C} \times 100\%$$

$$= 1.5\%$$

Dimensional Analysis

we use dimensional analysis to convert one quantity to another.

Dimensional analysis

$$\frac{2.54\text{cm}}{2.54\text{cm}} = \frac{1\text{ in}}{2.54\text{cm}}$$

dividing both sides of the equation by 2.54cm

$$1 = \frac{1\text{ in}}{2.54\text{cm}}$$

$$1 = \frac{2.54\text{cm}}{1\text{ in}}$$

we create an expression called a convertion factor

Dimensional Analysis

Use the form of the conversion factor that puts the sought-for unit in the numerator:

$$\cancel{\text{Given unit}} \times \frac{\text{desired unit}}{\cancel{\text{given unit}}} = \text{desired unit}$$

Conversion factor

Example

What is the length of a 2.85cm pin in inches?

$$2.85\ \text{cm} \times \frac{1\ \text{in}}{2.54\ \text{cm}} = 1.12\ \text{in}$$

Example

Where were you a billion seconds ago?

$$1\text{x}10^9\ \text{sec} \times \frac{1\ \text{min}}{60\ \text{sec}} \times \frac{1\ \text{hour}}{60\ \text{min}} \times \frac{1\ \text{day}}{24\ \text{hours}}$$

$$\times \frac{1\ \text{year}}{365\ \text{days}} = \mathbf{31.7\ years}$$