Outline

- Chemistry
- Scientific Method
- Measurements
- Significant Figures
- Units Conversions
- Density

Chemistry

Chemistry is the study of properties and behavior of matter

Matter is the physical material of the universe

anything that has mass and occupies volume

composed of particles (atoms or molecules)

exists in three physical states (phases)

solid	definite volume and shape…
liquid	definite volume, shape determined…
gas	volume and shape determined…

Scientific Method

Procedure for organizing and understanding observations in nature

General steps…

make observation, formulate hypothesis,

perform experiments, refine hypothesis

Set of hypotheses in agreement with experiments become a theory

Theories are explanations of natural phenomena

Scientific laws are statements of natural phenomena

Measurements

Quantitative observations (measurements) consist of a number and unit

Measurements in science use the metric system for units

Length	meter (m)	(~ 1 yd)
Mass	gram (g)	($1)
Volume	liter (L)	(~ 1 qt)

In 1999...

$125,000,000 Mars Climate Orbiter lost due to unit confusion!

Scientific notation used to represent very large (or small) numbers

product of two numbers:

1. between 1 and 10
2. power of 10

Consider:

$1 \times 10^2 = 100$

$5.6 \times 10^3 = 5600$

$13000 = 1.3 \times 10^4$

$4560 = 4.56 \times 10^3$

More…

$1 \times 10^{-2} = 0.01$

$4.3 \times 10^{-3} = 0.0043$

$0.26 = 2.6 \times 10^{-1}$

$0.0089 = 8.9 \times 10^{-3}$

And more…

$5283 = 5.283 \times 10^{3}$

$4{,}500{,}000{,}000 = 4.5 \times 10^{9}$

$0.000123 = 1.23 \times 10^{-4}$

Metric prefixes used to change size of unit

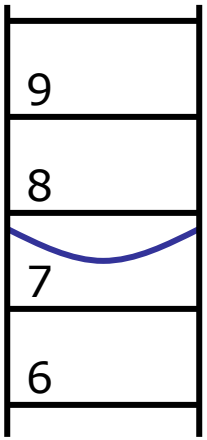
Prefix	Symbol	Meaning
mega	M	10^{6}
kilo	k	10^{3}
UNIT	-	10^{0}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

Instead of...

$1000\ m = 1 \times 10^{3}\ m = 1\ km$

$0.001\ g = 1 \times 10^{-3}\ g = 1\ mg$

All measurements have uncertainty, so last digit recorded is an estimate…

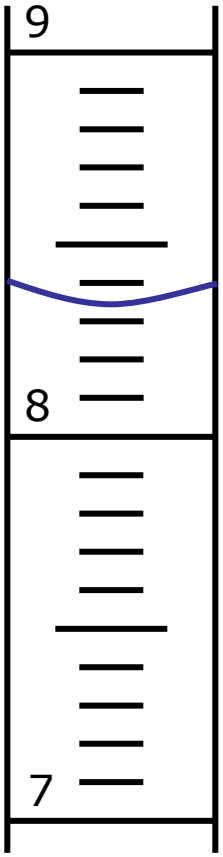


Uncertainty of might be given by manufacturer

If not, one-half of the closest divisions

One-half of 1 mL divisions is 0.5 mL

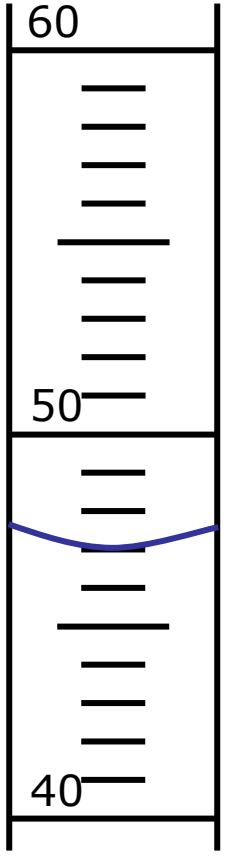
Device's uncertainty… tenth's place, measurement also made to the tenth's place



Division: 0.1 mL

Uncertainty: 0.05 mL

Measurement: <u>8.35 mL</u>



D: 1 mL

U: 0.5 mL

M: <u>47.0 mL</u>

Significant Figures

Every digit recorded in a measurement

All certain digits plus first uncertain digit

8.35 mL — 8 and 3 are certain

5 is uncertain

Significant figures are determined only for measurements…

Not for exact numbers:

counted numbers (7 apples purchased)

defined numbers (1 dozen)

Rules for Counting Significant Figures

1. All nonzero digits and trapped zeros are significant

596	22.75	3,901	707.1

2. Leading zeros are not significant

0.021	0.0035	0.0908	0.40602

3. Trailing zeros are significant with a decimal point

30.0	2700	106.0	0.7050

4. Trailing zeros can be made significant with a bar

$107\overline{0}$	$145\overline{00}$	$2054\overline{0}0$	0.34400

Adding/Subtracting Measurements

Answer's last digit will be in same place as last digit in least precise measurement

45.5 mL + 4.016 mL = ? = 49.5<u>1</u>6 mL = <u>49.5 mL</u>

2.45 g + 3.6452 g + 0.04 g = ? = 6.1<u>3</u>52 g = <u>6.14 g</u>

When rounding...

1. Look to digit following last sig fig

2. If less than 5, don't change last sig fig

3. Otherwise, increase last sig fig by 1

Multiplying/Dividing Measurements

Number of sig figs in the answer will equal the number of sig figs in the factor with least number of sig figs

1.023 cm x 4.5 cm = ? = 4.<u>6</u>03 cm^2 = <u>4.6 cm^2</u>

6.45 mL x 0.25 mL ÷ 1.61 mL = ? = 1.<u>0</u>01 mL = <u>1.0 mL</u>

Do not round until the end in multiple calculations…

(3.111 + 5.03) x (100 + 33) = ?

Right: (8.1<u>4</u>1) x (<u>1</u>33) = <u>1</u>082.753 = <u>1000</u>

Wrong: (8.1<u>4</u>) x (<u>1</u>00) = <u>8</u>14 = <u>800</u>

Unit Conversions

Converting from one unit to another…

write information line with given and unknown

develop equivalence statements between units

check for unit cancellation and solve

How many km in 421 m?

$421\,\text{m} \times (\text{factor}) = ?\,\text{km}$

$1\,\text{km} = 1 \times 10^3\,\text{m} \quad \Rightarrow \quad \frac{1\,\text{km}}{1 \times 10^3\,\text{m}}$

$421\,\text{m} \times \frac{1\,\text{km}}{1 \times 10^3\,\text{m}} = \underline{0.421\,\text{km}}$

How many mm in 2.5 m?

$2.5\ \text{m} \times (\text{factor}) = ?\ \text{mm}$

$1\ \text{mm} = 1 \times 10^{-3}\ \text{m} \quad \Rightarrow \quad \frac{1\ \text{mm}}{1 \times 10^{-3}\ \text{m}}$

$2.5\ \text{m} \times \frac{1\ \text{mm}}{1 \times 10^{-3}\ \text{m}} = \underline{2500\ \text{mm}}$

How many L in 1 gal?

$1\ \text{gal} \times (\text{factor}) = ?\ \text{L}$

$1\ \text{L} = 1.057\ \text{qt} \quad \Rightarrow \quad \frac{1\ \text{L}}{1.057\ \text{qt}} \qquad 1\ \text{gal} = 4\ \text{qt} \quad \Rightarrow \quad \frac{4\ \text{qt}}{1\ \text{gal}}$

$1\ \text{gal} \times \frac{4\ \text{qt}}{1\ \text{gal}} \times \frac{1\ \text{L}}{1.057\ \text{qt}} = \underline{3}.784\ \text{L} = \underline{4\ \text{L}}$

There are 1.057 qt in 1 L, how many mL in 1.5 gal?

$$1.5\ \text{gal} \times (\text{factor}) = ?\ \text{mL}$$

$$1\ \text{gal} = 4\ \text{qt} \quad \Rightarrow \quad \frac{4\ \text{qt}}{1\ \text{gal}}$$

$$1.057\ \text{qt} = 1\ \text{L} \quad \Rightarrow \quad \frac{1\ \text{L}}{1.057\ \text{qt}}$$

$$1\ \text{mL} = 1 \times 10^{-3}\ \text{L} \quad \Rightarrow \quad \frac{1\ \text{mL}}{1 \times 10^{-3}\ \text{L}}$$

$$1.5\ \text{gal} \times \frac{4\ \text{qt}}{1\ \text{gal}} \times \frac{1\ \text{L}}{1.057\ \text{qt}} \times \frac{1\ \text{mL}}{1 \times 10^{-3}\ \text{L}} = 5676\ \text{mL} = \underline{5700\ \text{mL}}$$

There are 2.54 cm in 1 in, how many μm^2 in 0.04723 in^2?

$$0.04723\ in^2 \text{ x (factor)} = ?\ \mu m^2$$

$$2.54\ cm = 1\ in \Rightarrow \frac{2.54\ cm}{1\ in} \Rightarrow \frac{2.54^2\ cm^2}{1\ in^2}$$

$$1\ cm = 1 \text{ x } 10^{-2}\ m \Rightarrow \frac{1 \text{ x } 10^{-2}\ m}{1\ cm} \Rightarrow \frac{1 \text{ x } 10^{-4}\ m^2}{1\ cm^2}$$

$$1\ \mu m = 1 \text{ x } 10^{-6}\ m \Rightarrow \frac{1\ \mu m}{1 \text{ x } 10^{-6}\ m} \Rightarrow \frac{1\ \mu m^2}{1 \text{ x } 10^{-12}\ m^2}$$

$$0.04723\ in^2 \text{ x } \frac{2.54^2\ cm^2}{1\ in^2} \text{ x } \frac{1 \text{ x } 10^{-4}\ m^2}{1\ cm^2} \text{ x } \frac{1\ \mu m^2}{1 \text{ x } 10^{-12}\ m^2}$$

$$= 304\underline{7}0906.8\ \mu m^2 = \underline{3.047 \text{ x } 10^7\ \mu m^2}$$

Density

Density is the mass of a substance occupying a unit volume

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

Density units vary…

solids	g/cm^3 (1 mL = 1 cm^3)
liquids	g/mL
gases	g/L

If an object's density is…

greater than a liquid's, it sinks!

less than a liquid's, it floats!

Before…

After…

A 23.0 g object has a volume of 5.8 cm^3. What's the density?

$$\text{Density} = \frac{23.0\ \text{g}}{5.8\ \text{cm}^3} = 3.\underline{9}6\ \text{g/cm}^3 = \underline{4.0\ \text{g/cm}^3}$$

What's the mass of 110 mL of chloroform (1.49 g/mL)?

$$110\ \text{mL x (factor)} = ?\ \text{g}$$

$$110\ \text{mL x } \frac{1.49\ \text{g}}{1\ \text{mL}} = 1\underline{6}3.9\ \text{g} = \underline{160\ \text{g}}$$

What's the volume of 56 g of chloroform (same density)?

$$56\ \text{g x (factor)} = ?\ \text{mL}$$

$$56\ \text{g x } \frac{1\ \text{mL}}{1.49\ \text{g}} = 3\underline{7}.5\ \text{mL} = \underline{38\ \text{mL}}$$