Chem With Com

Measurements, Prefixes and Dimensional Analysis

- Chapter 1.4 (Measurements)
- Chapter 1.5 (Measurement Uncertainty, Accuracy, and Precision)
- Appendix B (Essential Mathematics)
- Chapter 1.6 (Mathematical Treatment of Measurement Results)
- Appendix C (Units and Conversion Factors)
- 2.4 (Chemical Formulas)

Adapted From: Paul Flowers, Edward J. Neth, William R. Robinson, PhD, Klaus Theopold, Richard Langley; Chemistry: Atoms First 2e; OpenStax; Feb 14, 2019; Houston Texas; https://openstax.org/books/chemistry-atoms-first-2e/pages/1-introduction

Units, Measurements, and Density

- Chapter 1.4 (Measurements)
- Chapter 1.5 (Measurement Uncertainty, Accuracy, and Precision)

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Units make numbers meaningful in chemistry

1	1 what?
1 dollar	now this has meaning
1 gram	now this has meaning
1.00 gram	what is the difference having the ".00"?

1350 grams
1.350 kilograms
1.350×10^3 grams

} these are all the same number

Le Système International d'Unités **(SI Units)**

Base Units of the SI System

Property Measured	Name of Unit	Symbol of Unit
length	meter	m
mass	kilogram	kg
time	second	s
temperature	kelvin or Celsius	K or °C
electric current	ampere	A
amount of substance	mole	mol
luminous intensity	candela	cd

Table 1.2

volume	liter	L

- Measured numbers - last digit is an estimate/guess – all are significant
- Counted numbers – these are exact numbers – infinite significant figures

Length (distance) = meter (m)

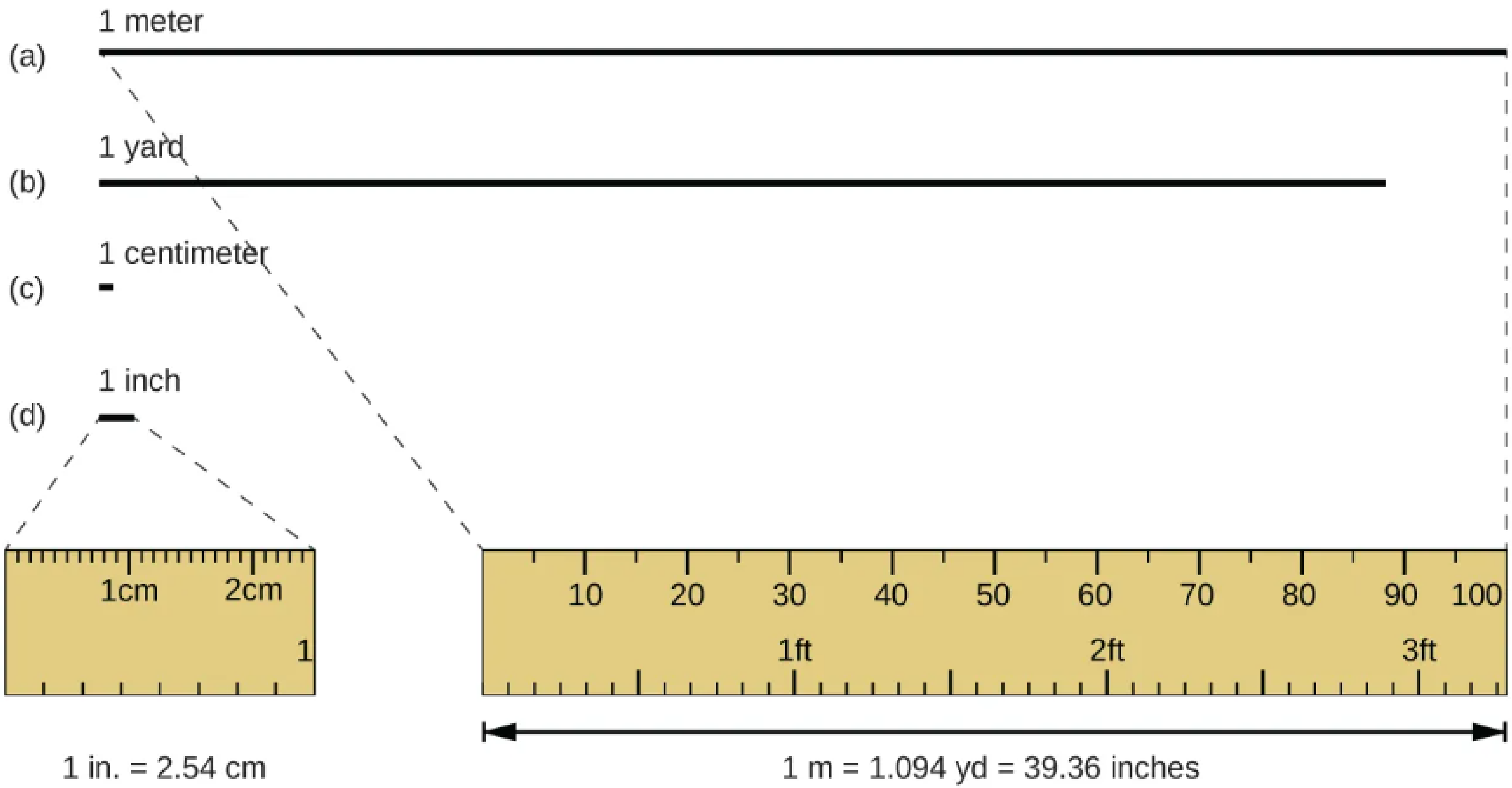


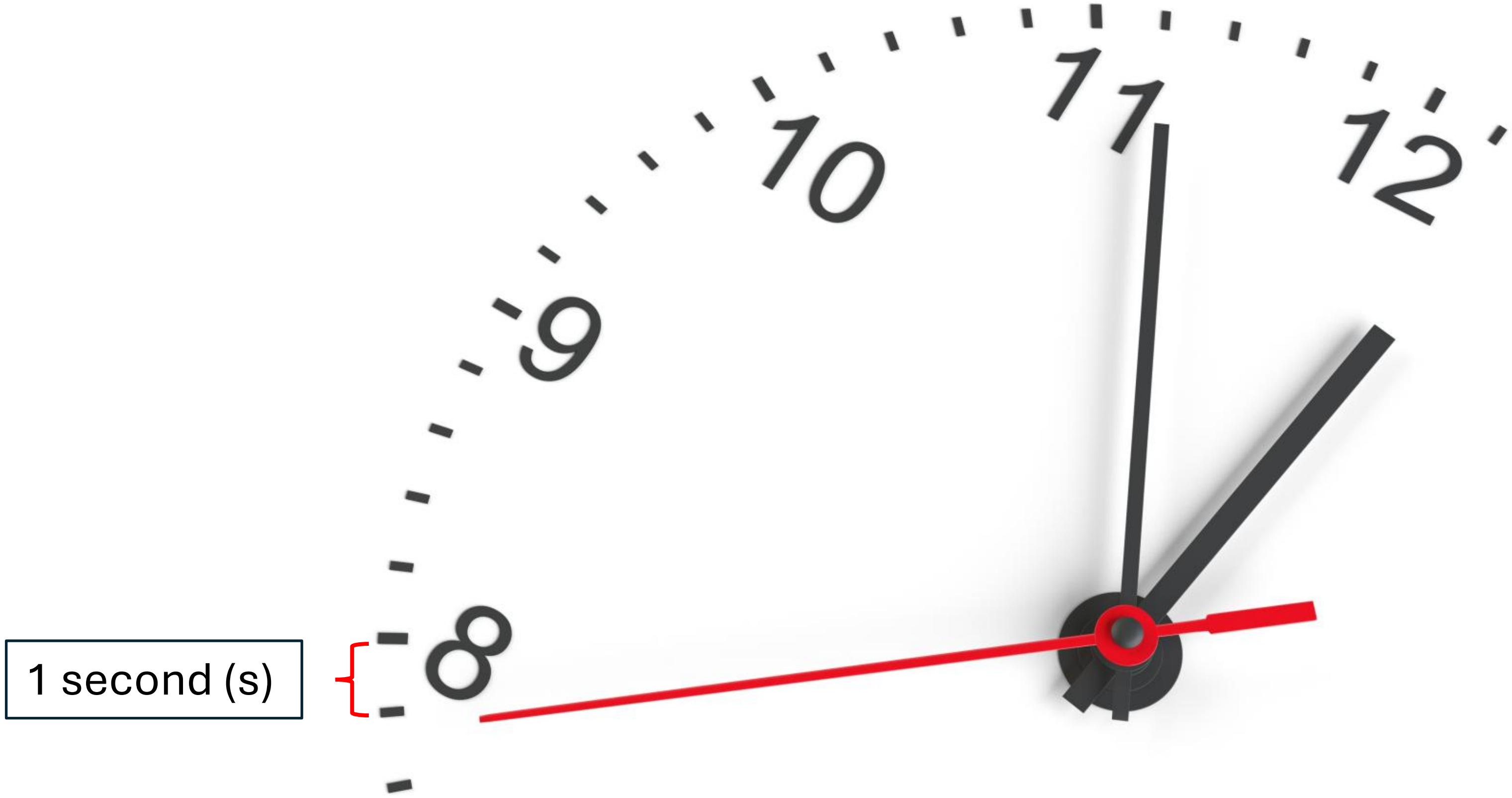
Figure 1.23 The relative lengths of 1 m, 1 yd, 1 cm, and 1 in. are shown (not actual size), as well as comparisons of 2.54 cm and 1 in., and of 1 m and 1.094 yd.

Mass (how much matter or "stuff") – kilogram (kg)

- Used to be 1 liter of water = 1 kg
- Typically a balance or scale will measure mass
- Weight is the force of gravity on mass
- Weight is the same as mass on earth

Figure 1.24 This replica prototype kilogram as previously defined is housed at the National Institute of Standards and Technology (NIST) in Maryland. (credit: National Institutes of Standards and Technology)

Time (progression of existence) – seconds (s)



Temperature (average energy) – kelvin (K) or Celsius (°C)

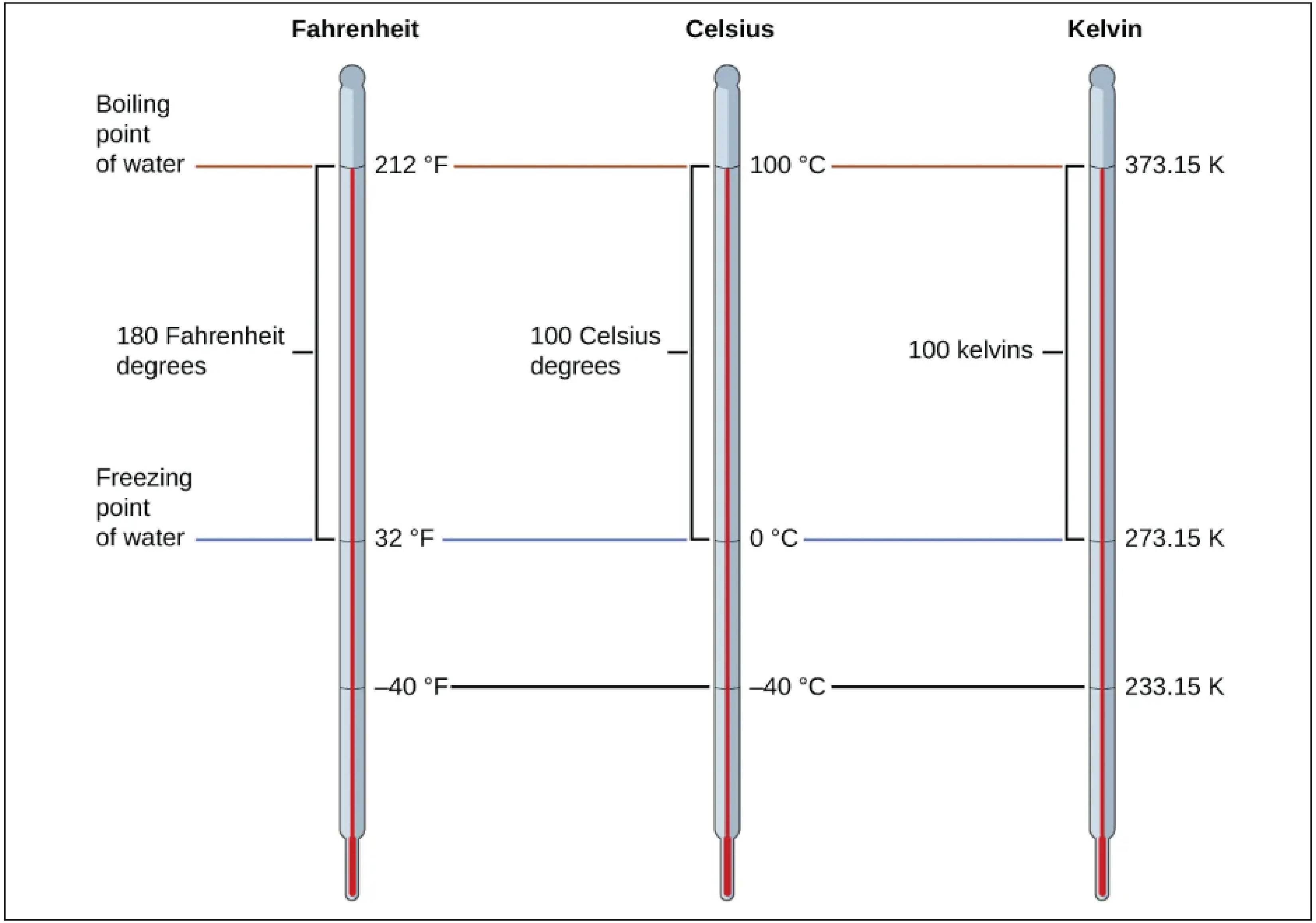


Figure 1.28 The Fahrenheit, Celsius, and kelvin temperature scales are compared.

Moles (number of things) – 6.022×10^{23} things – moles (mol)

Mole is just a word that means a number, similar to how "dozen" means "twelve"

602,200,000,000,000,000,000,000 things (usually atoms/molecules)

6.022×10^{23} things (usually atoms/molecules)

- Measured numbers - last digit is an estimate/guess – all are significant
- Counted numbers – these are exact numbers – infinite significant figures

**If you are counting a mole of things – that is an exact number. If you are calculating or measuring the amount of something in moles, that is a measured number

Volume (how much space something takes) – liter (L)

- Important Equivalencies
  - $1\ cm^3 = 1\ mL$
  - $1000\ cm^3 = 1\ L$

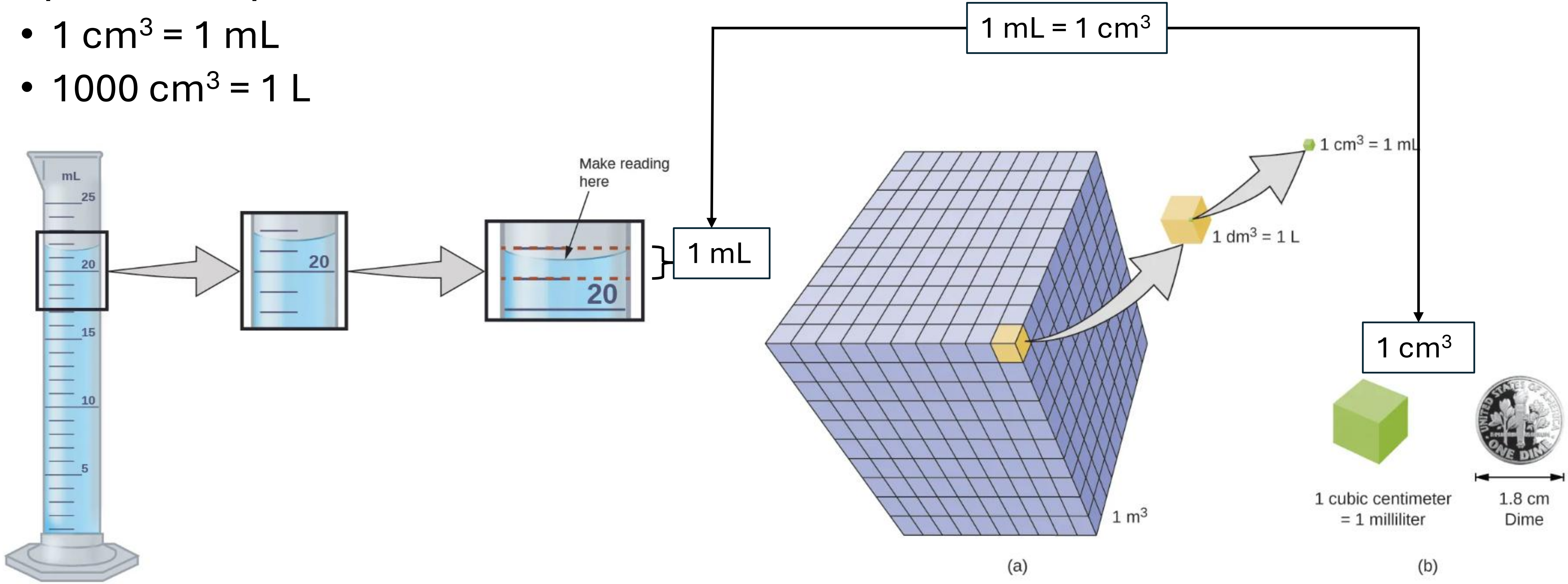


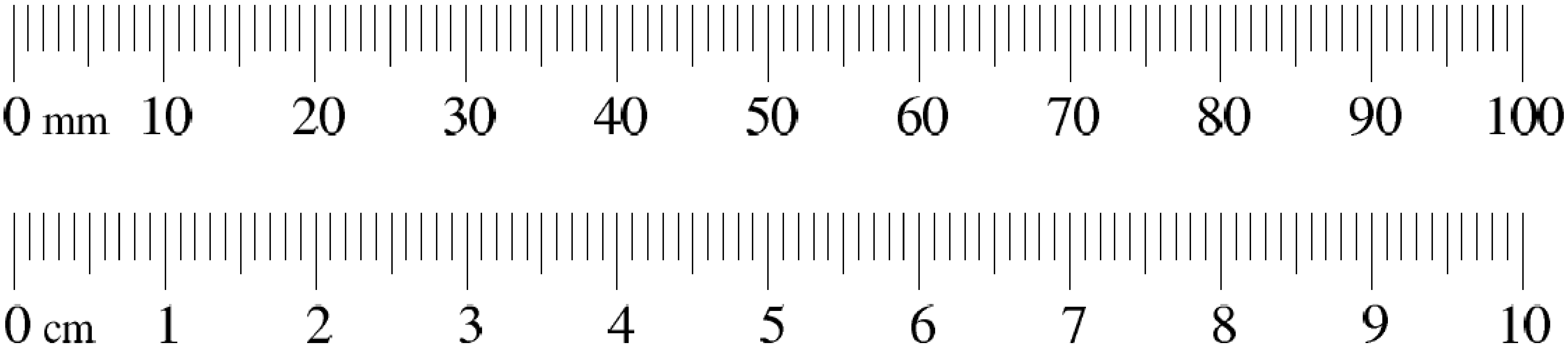
Figure 1.26 To measure the volume of liquid in this graduated cylinder, you must mentally subdivide the distance between the 21 and 22 mL marks into tenths of a milliliter, and then make a reading (estimate) at the bottom of the meniscus.

Figure 1.25 (a) The relative volumes are shown for cubes of $1\ m^3$, $1\ dm^3$ (1 L), and $1\ cm^3$ (1 mL) (not to scale). (b) The diameter of a dime is compared relative to the edge length of a $1\text{-}cm^3$ (1-mL) cube.

Length (distance)

1 m = 100 cm = 1000 mm

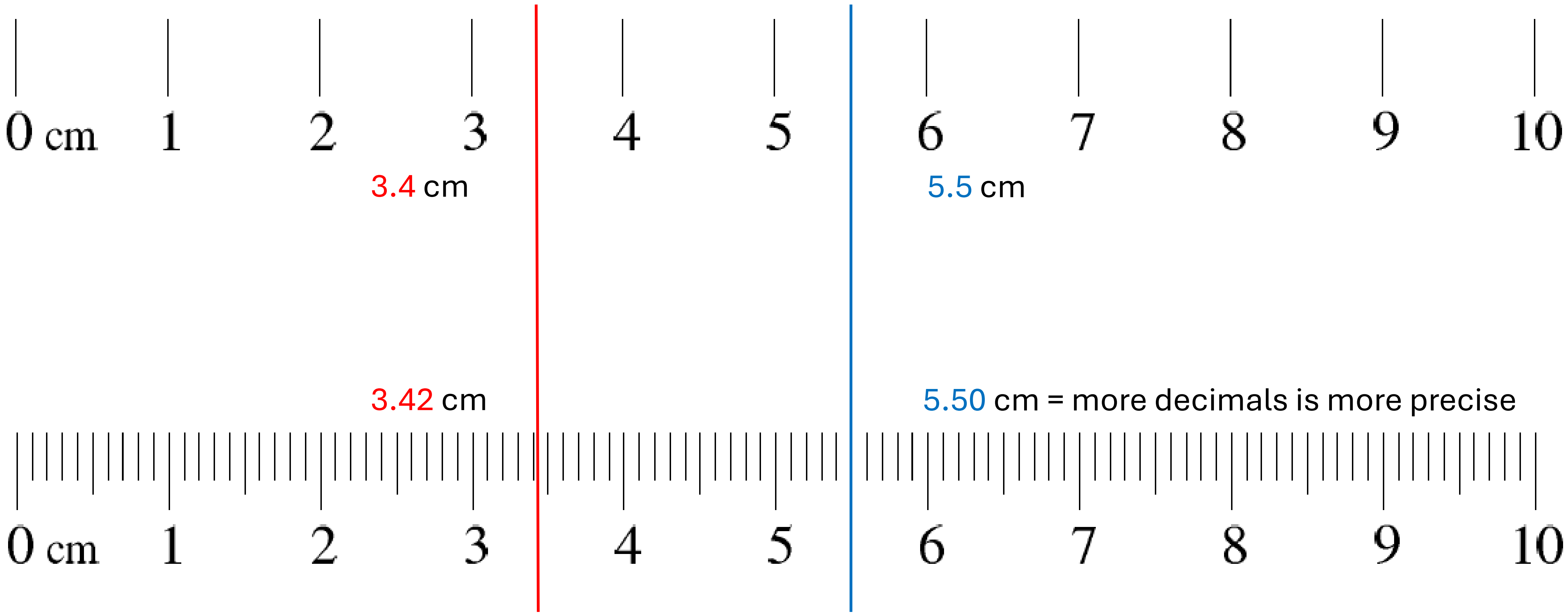
10 mm = 1 cm



Chapter 1.4, http://www.vendian.org/mncharity/dir3/paper_rulers/

Length (distance)

- More accurate – closer to the “true” measurement
- More precise – the results are closer when measured the same way



- Top ruler cannot be read to 2 decimal places because there aren’t enough measurement marks
- Bottom ruler can be read to 2 decimal places so all measurements must be to 2 decimal places

Chapter 1.4, http://www.vendian.org/mncharity/dir3/paper_rulers/

Volume (how much space something takes) – liter (L)

- Important Equivalencies
  - 1 cm^3 = 1 mL
  - 1000 cm^3 = 1 L

Need to read from the bottom of the curve (meniscus)

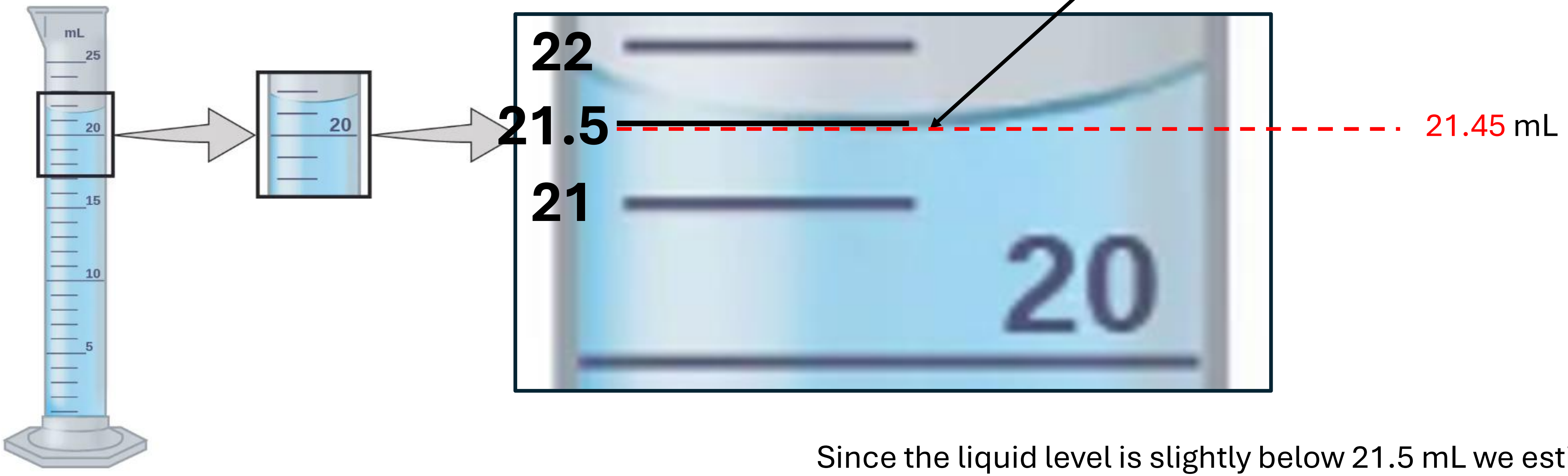


Figure 1.26 To measure the volume of liquid in this graduated cylinder, you must mentally subdivide the distance between the 21 and 22 mL marks into tenths of a milliliter, and then make a reading (estimate) at the bottom of the meniscus.

Since the liquid level is slightly below 21.5 mL we estimate the number to be 21.45 mL but someone could also say 21.48 mL and they would both be "correct". Since this can be reported with 2 decimal places, all measurements from this device should be reported with 2 decimal places.

Density (how much mass in a certain volume) – mass/volume (usually g/mL)

- Important Equivalencies
  - 1 cm^3 = 1 mL
  - 1000 cm^3 = 1 L

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{\text{grams}}{\text{milliliters or cubic centimeters}} = \frac{g}{mL} = \frac{g}{cm \times cm \times cm} = \frac{g}{cm^3}$$

We use the mass and volume of a substance to determine its density. Thus, the units of density are defined by the base units of mass and length.

The **density** of a substance is the ratio of the mass of a sample of the substance to its volume.

Densities of Common Substances

Solids	**Liquids**	**Gases (at 25 °C and 1 atm)**
ice (at 0 °C) 0.92 g/cm^3	water 1.0 g/cm^3	dry air 1.20 g/L
oak (wood) 0.60–0.90 g/cm^3	ethanol 0.79 g/cm^3	oxygen 1.31 g/L
iron 7.9 g/cm^3	acetone 0.79 g/cm^3	nitrogen 1.14 g/L
copper 9.0 g/cm^3	glycerin 1.26 g/cm^3	carbon dioxide 1.80 g/L
lead 11.3 g/cm^3	olive oil 0.92 g/cm^3	helium 0.16 g/L
silver 10.5 g/cm^3	gasoline 0.70–0.77 g/cm^3	neon 0.83 g/L
gold 19.3 g/cm^3	mercury 13.6 g/cm^3	radon 9.1 g/L

Table 1.4

Check Your Learning

(a) To three decimal places, what is the volume of a cube (cm^3) with an edge length of 0.843 cm?

(b) If the cube in part (a) is copper and has a mass of 5.34 g, what is the density of copper to two decimal places?

Prefixes and Exponential Notation

- Chapter 1.4 (Measurements)
- Appendix B (Essential Mathematics)

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Your calculator will be very important!

- Get a non-phone calculator ASAP!
- Practice with it during every lecture/video
- Use the same one for lecture/video, assignments, and exams
- Free Online Calculators (but you need to have a physical one for the exams:
  - https://ti84calc.com/
  - https://ti84ce.com/
  - https://www.desmos.com/scientific
  - Search free online scientific calculator

Unit Prefixes and Exponential Notation

Common Unit Prefixes

Prefix	Symbol	Factor	Example
femto	f	10^{-15}	1 femtosecond (fs) = 1×10^{-15} s (0.000000000000001 s)
pico	p	10^{-12}	1 picometer (pm) = 1×10^{-12} m (0.000000000001 m)
nano	n	10^{-9}	4 nanograms (ng) = 4×10^{-9} g (0.000000004 g)
micro	µ	10^{-6}	1 microliter (µL) = 1×10^{-6} L (0.000001 L)
milli	m	10^{-3}	2 millimoles (mmol) = 2×10^{-3} mol (0.002 mol)
centi	c	10^{-2}	7 centimeters (cm) = 7×10^{-2} m (0.07 m)
deci	d	10^{-1}	1 deciliter (dL) = 1×10^{-1} L (0.1 L)
kilo	k	10^{3}	1 kilometer (km) = 1×10^{3} m (1000 m)
mega	M	10^{6}	3 megahertz (MHz) = 3×10^{6} Hz (3,000,000 Hz)
giga	G	10^{9}	8 gigayears (Gyr) = 8×10^{9} yr (8,000,000,000 yr)
tera	T	10^{12}	5 terawatts (TW) = 5×10^{12} W (5,000,000,000,000 W)

Table 1.3

Exponential notation is used in prefixes

Exponential notation is used to express very large and very small numbers as a product of two numbers. The first number of the product, the *digit term*, is usually a number not less than 1 and not equal to or greater than 10. The second number of the product, the *exponential term*, is written as 10 with an exponent. Some examples of exponential notation are:

$$\begin{aligned} 1000 &= 1 \times 10^3 \\ 100 &= 1 \times 10^2 \\ 10 &= 1 \times 10^1 \\ 1 &= 1 \times 10^0 \\ 0.1 &= 1 \times 10^{-1} \\ 0.001 &= 1 \times 10^{-3} \end{aligned}$$

Prefix	**Symbol**	**Factor**	**Example**
femto	f	10^{-15}	1 femtosecond (fs) = 1×10^{-15} s (0.000000000000001 s)
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micro	µ	10^{-6}	1 microliter (µL) = 1×10^{-6} L (0.000001 L)

Prefixes are just words that mean numbers

kilo	k	10^3	1 kilometer (km) = 1 × 10^3 m (1000 m)

1357 grams
1.357 kilograms
1.357 x 10^3 grams

} these are all the same number

kilo = 10^3

kilo = $10^3 = 10^1 \times 10^1 \times 10^1 = 1000$

or

= $10^3 = 10 \times 10 \times 10 = 1000$

Prefixes are just words that mean numbers

micro	μ	10^{-6}	1 microliter (μL) = 1 × 10^{-6} L (0.000001 L)

270 microliters
270 x 10^{-6} liters

these are the same number

micro = 10^{-6}

micro = $10^{-6} = 10^{-1} \times 10^{-1} \times 10^{-1} \times 10^{-1} \times 10^{-1} \times 10^{-1} = 0.000001$

or

$$10^{-6} = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} = 0.000001$$

Le Système International d'Unités (SI Units)

Base Units of the SI System

Property Measured	Name of Unit	Symbol of Unit
length	meter	m
mass	kilogram	kg
time	second	s
temperature	kelvin or Celsius	K or ºC
electric current	ampere	A
amount of substance	mole	mol
luminous intensity	candela	cd

Table 1.2

volume	liter	L

Units and Prefixes

1357.0 grams
1.3570 kilograms
1.3570 x 10^3 grams

these are all the same number

Common Unit Prefixes

Prefix	Symbol	Factor	Example
femto	f	10^{-15}	1 femtosecond (fs) = 1 × 10^{-15} s (0.000000000000001 s)
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luminous intensity	candela	cd

Table 1.2

volume	liter	L

Prefixes work with any unit

1.3570 kilograms = 1.3570 x 10^3 grams = 1.3570 x 1000 grams

grams

1 kilogram (kg) = 10^3 grams (g) = 1000 grams (g)

1 kiloliter (kL) = 10^3 liter (L) = 1000 liters (L)

1 kilomole (mol) = 10^3 moles (mol) = 1000 moles (mol)

Common Unit Prefixes

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Table 1.3

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Table 1.2

volume	liter	L

Exponential Notation

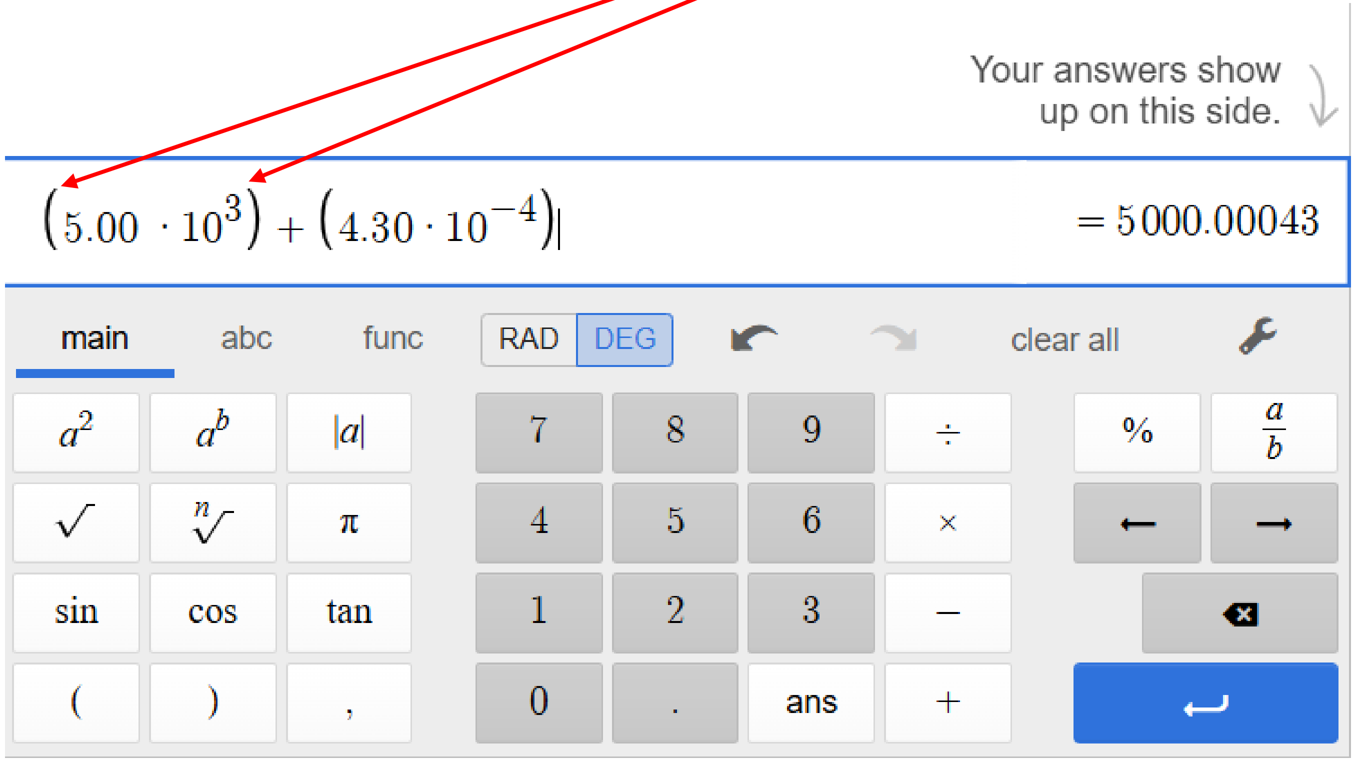
- The decimal moves amount of times as the number in the exponent.
  - For something like 3.05×10^4, you would move the decimal 4 places, since the exponent is positive, you know the final number will be greater than 1.
  - For something like 2.1×10^{-3}, you would move the decimal 3 place, since the exponent is negative, you know the final number will be less than 1.
  - For 0.0078077, you would move the decimal 3 places to get to the first non-zero digit. If the number started as a number less than 1, it is a negative exponent.
  - For 97,105,000 you would move the decimal 7 places to get to the first non-zero digit. If the number started as a number greater than 1, it is a positive exponent.

Use brackets ( ) around any exponential notation numbers when using your calculator

Example problem

$5.00 \times 10^{3} + 4.30 \times 10^{-4}$

Use brackets in your calculator until you know what you're doing



Math and Exponents – addition

Addition of Exponentials

Convert all numbers to the same power of 10, add the digit terms of the numbers, and if appropriate, convert the digit term back to a number between 1 and 10 by adjusting the exponential term.

EXAMPLE B1

Adding Exponentials

Add 5.00×10^{-5} and 3.00×10^{-3}.

Solution

$$\begin{aligned} 3.00 \times 10^{-3} &= 300 \times 10^{-5} \\ (5.00 \times 10^{-5}) + (300 \times 10^{-5}) &= 305 \times 10^{-5} = 3.05 \times 10^{-3} \end{aligned}$$

Easiest way -> put it into your calculator! Use brackets for exponential notation numbers and don't forget significant figures!

Math and Exponents – subtraction

Subtraction of Exponentials

Convert all numbers to the same power of 10, take the difference of the digit terms, and if appropriate, convert the digit term back to a number between 1 and 10 by adjusting the exponential term.

EXAMPLE B2

Subtracting Exponentials

Subtract 4.0×10^{-7} from 5.0×10^{-6}.

Solution

$$4.0 \times 10^{-7} = 0.40 \times 10^{-6}$$
$$(5.0 \times 10^{-6}) - (0.40 \times 10^{-6}) = 4.6 \times 10^{-6}$$

Easiest way -> put it into your calculator! Use brackets for exponential notation numbers and don't forget significant figures!

Math and Exponents – multiplication

Multiplication of Exponentials

Multiply the digit terms in the usual way and add the exponents of the exponential terms.

EXAMPLE B3

Multiplying Exponentials

Multiply 4.2×10^{-8} by 2.0×10^{3}.

Solution

$$(4.2 \times 10^{-8}) \times (2.0 \times 10^{3}) = (4.2 \times 2.0) \times 10^{(-8)+(+3)} = 8.4 \times 10^{-5}$$

Easiest way -> put it into your calculator! Use brackets for exponential notation numbers and don't forget significant figures!

Math and Exponents – division

Division of Exponentials

Divide the digit term of the numerator by the digit term of the denominator and subtract the exponents of the exponential terms.

EXAMPLE B4

Dividing Exponentials

Divide 3.6×10^{-5} by 6.0×10^{-4}.

Solution

$$\frac{3.6 \times 10^{-5}}{6.0 \times 10^{-4}} = \left(\frac{3.6}{6.0}\right) \times 10^{(-5)-(-4)} = 0.60 \times 10^{-1} = 6.0 \times 10^{-2}$$

Easiest way -> put it into your calculator! Use brackets for exponential notation numbers and don't forget significant figures!

Dimensional Analysis

- Chapter 1.6 (Mathematical Treatment of Measurement Results)
- Appendix C (Units and Conversion Factors)

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  - https://ti84ce.com/
  - https://www.desmos.com/scientific
  - Search free online scientific calculator
- Put brackets around all exponential notation numbers when using your calculator!

Dimensional analysis is just converting things from one unit to another

Step 1: find the conversion rate

Step 2: write it as two fractions

Step 3: multiply the original value by the fraction

Dimensional analysis is just converting things from one unit to another

Convert $1.00 USD (US dollars) to MXN (Mexican Pesos)

Step 1: find the conversion rate — 1.00 USD = 17.29 MXN (conversion factors are "exact" numbers)

Step 2: write it as two fractions — $\frac{17.29\ MXN}{1.00\ USD}$ or $\frac{1.00\ USD}{17.29\ MXN}$

Step 3: multiply the original value by the fraction — $1.00\ USD\ x\ \frac{17.29\ MXN}{1.00\ USD} = 17.29\ MXN$

Answer: 17.29 MXN --> 17.3 MXN (sigfigs)

Dimensional analysis is just converting things from one unit to another

Convert $13.50 USD (US dollars) to MXN (Mexican Pesos)

Step 1: find the conversion rate 1.00 USD = 17.29 MXN

conversion factors are "exact" numbers

Step 2: write it as two fractions $\frac{17.29\ MXN}{1.00\ USD}$ or $\frac{1.00\ USD}{17.29\ MXN}$

Step 3: multiply the original value by the fraction

$$13.50\ USD\ x\ \frac{17.29\ MXN}{1.00\ USD} = 233.415\ MXN$$

Answer: 233.415 MXN --> 233.4 MXN (sigfigs)

Dimensional analysis is just converting things from one unit to another

Convert 150.00 MXN (Mexican Pesos) to USD (US dollars)

Step 1: find the conversion rate 1.00 USD = 17.29 MXN

conversion factors are “exact” numbers

Step 2: write it as two fractions $\frac{17.29\ MXN}{1.00\ USD}$ or $\frac{1.00\ USD}{17.29\ MXN}$

Step 3: multiply the original value by the fraction $150.00\ MXN\ x\ \frac{1.00\ USD}{17.29\ MXN} = 8.67553\ USD$

Answer: 8.67553 USD --> 8.6755 USD (sigfigs)

Step 1: Find the conversion rate (or factor)

Conversion Factors and Dimensional Analysis

A ratio of two equivalent quantities expressed with different measurement units can be used as a **unit conversion factor**. For example, the lengths of 2.54 cm and 1 in. are equivalent (by definition), and so a unit conversion factor may be derived from the ratio,

Several other commonly used conversion factors are given in Table 1.6.

Common Conversion Factors

Length	Volume	Mass
1 m = 1.0936 yd	1 L = 1.0567 qt	1 kg = 2.2046 lb
1 in. = 2.54 cm (exact)	1 qt = 0.94635 L	1 lb = 453.59 g[2]
1 km = 0.62137 mi	1 ft^3 = 28.317 L	1 (avoirdupois) oz = 28.349 g
1 mi = 1609.3 m	1 tbsp = 14.787 mL	1 (troy) oz = 31.103 g

Table 1.6

NOTE: All conversion rates (or conversion factors) must have the following:

- A number with a unit
- An equals sign
- A number with a different unit

Step 2: Write the conversion rate as two fractions

$$\frac{2.54 \text{ cm}}{1 \text{ in.}} \ (2.54 \text{ cm} = 1 \text{ in.}) \text{ or } 2.54 \frac{\text{cm}}{\text{in.}}$$

Several other commonly used conversion factors are given in Table 1.6.

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1 mi = 1609.3 m	1 tbsp = 14.787 mL	1 (troy) oz = 31.103 g

Table 1.6

$$\frac{2.54\ cm}{1\ in} \qquad \frac{1\ in}{2.54\ cm}$$

Step 3: Multiply the original value by the fraction

When a quantity (such as distance in inches) is multiplied by an appropriate unit conversion factor, the quantity is converted to an equivalent value with different units (such as distance in centimeters). For example, a basketball player's vertical jump of 34 inches can be converted to centimeters by:

$$34\ \cancel{\text{in.}} \times \frac{2.54\ \text{cm}}{1\ \cancel{\text{in.}}} = 86\ \text{cm}$$

Since this simple arithmetic involves *quantities*, the premise of dimensional analysis requires that we multiply both *numbers and units*. The numbers of these two quantities are multiplied to yield the number of the product quantity, 86, whereas the units are multiplied to yield $\frac{\text{in.} \times \text{cm}}{\text{in.}}$. Just as for numbers, a ratio of identical units is also numerically equal to one, $\frac{\text{in.}}{\text{in.}} = 1$, and the unit product thus simplifies to *cm*. (When identical units divide to yield a factor of 1, they are said to "cancel.") Dimensional analysis may be used to confirm the proper application of unit conversion factors as demonstrated in the following example.

Important notes:

- Use the fraction that has the same units as the original value on the bottom of the fraction
- Cancel out any units that are the same

Practice Problem – 1 step conversion

Convert 3.97 nanometers to meters

Step 1: find the conversion rate

1 nanometer (nm) = 10^{-9} meters (m)

Step 2: write it as two fractions

$$\frac{1\,nm}{10^{-9}m} \quad \text{or} \quad \frac{10^{-9}m}{1\,nm}$$

Step 3: Multiply the original value by the fraction. Use the fraction that has the same unit as the original value on the bottom. Cancel out any units.

$$3.97\,\cancel{nm}\;x\;\frac{10^{-9}m}{1\,\cancel{nm}} = 3.97\,x\,10^{-9}m$$

Common Unit Prefixes

Prefix	Symbol	Factor	Example
femto	f	10^{-15}	1 femtosecond (fs) = 1 × 10^{-15} s (0.000000000000001 s)
pico	p	10^{-12}	1 picometer (pm) = 1 × 10^{-12} m (0.000000000001 m)
nano	n	10^{-9}	4 nanograms (ng) = 4 × 10^{-9} g (0.000000004 g)
micro	μ	10^{-6}	1 microliter (μL) = 1 × 10^{-6} L (0.000001 L)
milli	m	10^{-3}	2 millimoles (mmol) = 2 × 10^{-3} mol (0.002 mol)
centi	c	10^{-2}	7 centimeters (cm) = 7 × 10^{-2} m (0.07 m)
deci	d	10^{-1}	1 deciliter (dL) = 1 × 10^{-1} L (0.1 L)
kilo	k	10^{3}	1 kilometer (km) = 1 × 10^{3} m (1000 m)
mega	M	10^{6}	3 megahertz (MHz) = 3 × 10^{6} Hz (3,000,000 Hz)
giga	G	10^{9}	8 gigayears (Gyr) = 8 × 10^{9} yr (8,000,000,000 yr)
tera	T	10^{12}	5 terawatts (TW) = 5 × 10^{12} W (5,000,000,000,000 W)

Table 1.3

Practice Problem – 2 step conversion

Convert 9.47 kilomoles (kmol) to micromoles (µmol)

Step 1: find the conversion rate

kilo	k	10^3	1 kilometer (km) = 1 × 10^3 m (1000 m)
micro	µ	10^{-6}	1 microliter (µL) = 1 × 10^{-6} L (0.000001 L)

We do not have a direct conversion rate from kilo to micro so we have to do a 2-step conversion.

Conversion 1: 1 kmol = 10^3 mol
Conversion 2: 1 µmol = 10^{-6} mol

Step 2: write both as two fractions

$\frac{1\ kmol}{10^3 mol}$ or $\frac{10^3 mol}{1\ kmol}$ and $\frac{10^{-6} mol}{1\ \mu mol}$ or $\frac{1\ \mu mol}{10^{-6} mol}$

Step 3: Multiply the original value by the fraction. Use the fraction that has the same unit as the original value on the bottom. Cancel out any units.

$$9.47\ \cancel{kmol}\ x\ \frac{10^3 mol}{1\ \cancel{kmol}} = 9.47\ x\ 10^3 mol$$

$$9.47\ x\ 10^3\ \cancel{mol}\ x\ \frac{1\ \mu mol}{10^{-6} \cancel{mol}} = 9.47\ x\ 10^9\ \mu mol$$

Then repeat this with the second conversion fraction

Check Your Learning

Convert a volume of 9.345 qt to liters.

Units of Volume

liter (L)	= 0.001 m^3 (exact, definition) = 1000 cm^3 (exact, definition) = 1.057 (US) quarts

Check Your Learning

What is the volume in liters of 1.000 oz, given that 1 L = 1.0567 qt and 1 qt = 32 oz (exactly)?

Check Your Learning

A Toyota Prius Hybrid uses 59.7 L gasoline to drive from San Francisco to Seattle, a distance of 1300 km (two significant digits).

(a) What (average) fuel economy, in miles per gallon, did the Prius get during this trip?

(b) If gasoline costs $3.90 per gallon, what was the fuel cost for this trip?

1 gallon = 4 quarts

mile (US)	= 1.60934 km

Table C1

Units of Volume

liter (L)	= 0.001 m^3 (exact, definition) = 1000 cm^3 (exact, definition) = 1.057 (US) quarts

Practice Problem

How many moles in 0.26 grams of carbon?

Conversion rate: 12.01 grams of carbon = 1 mole of carbon

12.01 g C = 1 mol C

$$\frac{12.01\ g\ C}{1\ mol\ C} \text{ or } \frac{1\ mol\ C}{12.01\ g\ C}$$

Element	Average Atomic Mass (amu)	Molar Mass (g/mol)	Atoms/Mole
C	12.01	12.01	6.022×10^{23}
H	1.008	1.008	6.022×10^{23}
O	16.00	16.00	6.022×10^{23}
Na	22.99	22.99	6.022×10^{23}
Cl	35.45	35.45	6.022×10^{23}

Practice Problem

How many atoms of sodium in 1.3 moles of sodium?

Conversion rate: 6.022×10^{23} atoms of sodium = 1 mole of sodium

6.022×10^{23} atoms Na = 1 mol Na

$$\frac{6.022\ x\ 10^{23} atoms\ Na}{1\ mol\ Na} \quad \text{or} \quad \frac{1\ mol\ Na}{6.022\ x\ 10^{23} atoms\ Na}$$

Element	Average Atomic Mass (amu)	Molar Mass (g/mol)	Atoms/Mole
C	12.01	12.01	6.022×10^{23}
H	1.008	1.008	6.022×10^{23}
O	16.00	16.00	6.022×10^{23}
Na	22.99	22.99	6.022×10^{23}
Cl	35.45	35.45	6.022×10^{23}

Temperature Conversions

Convert ^oF to ^oC $$T_{^\circ C} = \frac{5}{9}(T_{^\circ F} - 32)$$

Convert ^oC to ^oF $$T_{^\circ F} = \left(\frac{9}{5} \times T_{^\circ C}\right) + 32$$

Convert ^oC to K $$T_K = T_{^\circ C} + 273.15$$

Convert K to ^oC $$T_{^\circ C} = T_K - 273.15$$

Check Your Learning

Convert 80.92 °C to K and °F.

Convert ºF to ºC $$T_{°C} = \frac{5}{9}(T_{°F} - 32)$$

Convert ºC to ºF $$T_{°F} = \left(\frac{9}{5} \times T_{°C}\right) + 32$$

Convert ºC to K $$T_K = T_{°C} + 273.15$$

Convert K to ºC $$T_{°C} = T_K - 273.15$$

Dimensional Analysis (grams to moles to units)

- Chapter 2.4 (Chemical Formulas)

Adapted From: Paul Flowers, Edward J. Neth, William R. Robinson, PhD, Klaus Theopold, Richard Langley; Chemistry: Atoms First 2e; OpenStax; Feb 14, 2019; Houston Texas; https://openstax.org/books/chemistry-atoms-first-2e/pages/1-introduction

Your calculator will be very important!

- Get a non-phone calculator ASAP!
- Practice with it during every lecture/video, assignments, and the same one for exams
- Free Online Calculators (but you need to have a physical one for the exams:
  - https://ti84calc.com/
  - https://ti84ce.com/
  - https://www.desmos.com/scientific
  - Search free online scientific calculator
- Put brackets around all exponential notation numbers when using your calculator!

Dimensional analysis is just converting things from one unit to another

Convert 150.00 MXN (Mexican Pesos) to USD (US dollars)

Step 1: find the conversion rate 1.00 USD = 17.29 MXN

conversion factors are "exact" numbers

Step 2: write it as two fractions $\frac{17.29\ MXN}{1.00\ USD}$ or $\frac{1.00\ USD}{17.29\ MXN}$

Step 3: Multiply the original value by the fraction. Use the fraction that has the same unit as the original value on the bottom.

$$150.00\ MXN\ x\ \frac{1.00\ USD}{17.29\ MXN} = 8.67553\ USD$$

Answer: 8.67553 USD --> 8.6755 USD (sigfigs)

Avogadros number lets you convert from moles to units and from units to moles

Convert atoms to moles

Step 1: find the conversion rate 1 mole = $6.022\ x\ 1023\ units$

Step 2: write it as two fractions $\frac{6.022\ x\ 1023\ units}{1\ mol}$ or $\frac{1\ mol}{6.022\ x\ 1023\ units}$

Step 3: Multiply the original value by the fraction. Use the fraction that has the same unit as the original value on the bottom.

Answer:

Units = anything but usually molecules or atoms in this class

Grams per mole lets you convert from grams to moles and moles to grams

Convert moles of boron to grams of boron

Step 1: find the conversion rate $10.81\ g\ B = 1\ mol\ B$

Step 2: write it as two fractions $\frac{10.81\ g\ B}{1\ mol\ B}$ or $\frac{1\ mol\ B}{10.81\ g\ B}$

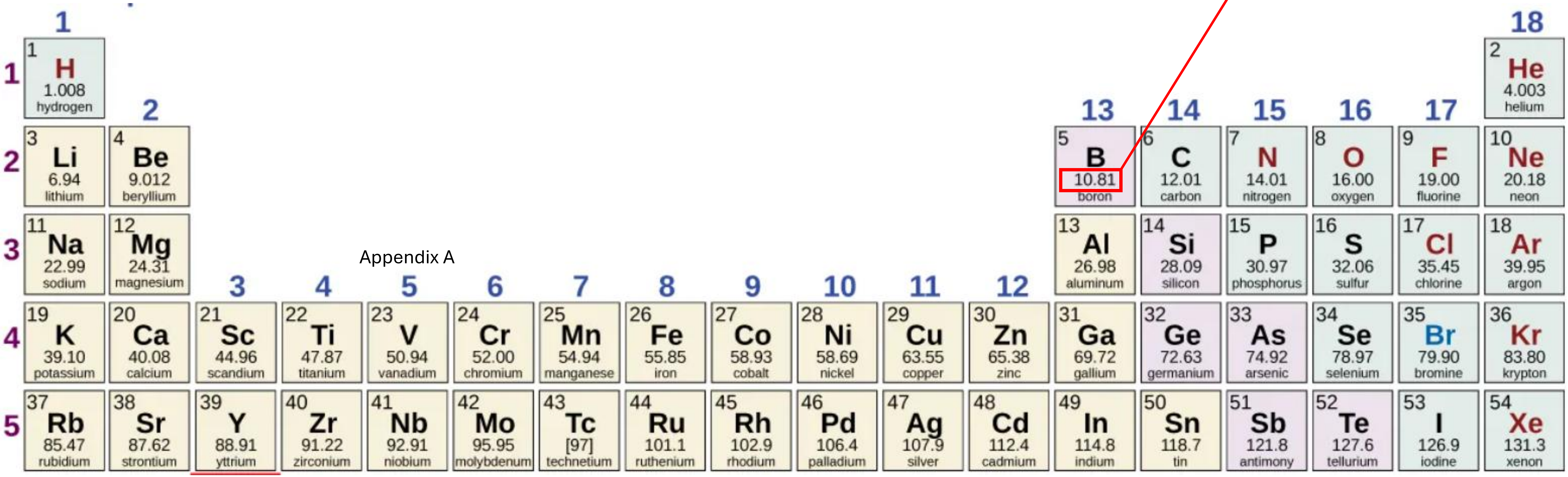
Step 3: Multiply the original value by the fraction. Use the fraction that has the same unit as the original value on the bottom.

Answer:

Grams per mole is found on the periodic table for atoms and molecules

$$10.81\ g\ B = 1\ mol\ B$$

$$\frac{10.81\ g\ B}{1\ mol\ B} \quad \text{or} \quad \frac{1\ mol\ B}{10.81\ g\ B}$$



Grams per mole is found on the periodic table for atoms and molecules

H x 2 x 1.008 g/mol = 2.016 g/mol
O x 1 x 16.00 g/mol = 16.00 g/mol

H_2O = 18.016 g/mol

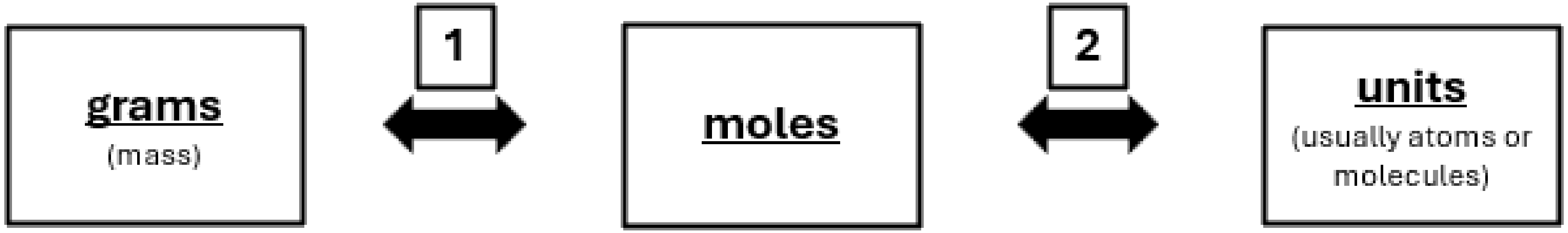
$$18.016\ g\ H_2O = 1\ mol\ H_2O$$

$$\frac{18.016\ g\ H_2O}{1\ mol\ H_2O} \quad \text{or} \quad \frac{1\ mol\ H_2O}{18.016\ g\ H_2O}$$

Appendix A

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H 1.008 hydrogen																	2 He 4.003 helium
2	3 Li 6.94 lithium	4 Be 9.012 beryllium											5 B 10.81 boron	6 C 12.01 carbon	7 N 14.01 nitrogen	8 O 16.00 oxygen	9 F 19.00 fluorine	10 Ne 20.18 neon
3	11 Na 22.99 sodium	12 Mg 24.31 magnesium											13 Al 26.98 aluminum	14 Si 28.09 silicon	15 P 30.97 phosphorus	16 S 32.06 sulfur	17 Cl 35.45 chlorine	18 Ar 39.95 argon
4	19 K 39.10 potassium	20 Ca 40.08 calcium	21 Sc 44.96 scandium	22 Ti 47.87 titanium	23 V 50.94 vanadium	24 Cr 52.00 chromium	25 Mn 54.94 manganese	26 Fe 55.85 iron	27 Co 58.93 cobalt	28 Ni 58.69 nickel	29 Cu 63.55 copper	30 Zn 65.38 zinc	31 Ga 69.72 gallium	32 Ge 72.63 germanium	33 As 74.92 arsenic	34 Se 78.97 selenium	35 Br 79.90 bromine	36 Kr 83.80 krypton
5	37 Rb 85.47 rubidium	38 Sr 87.62 strontium	39 Y 88.91 yttrium	40 Zr 91.22 zirconium	41 Nb 92.91 niobium	42 Mo 95.95 molybdenum	43 Tc [97] technetium	44 Ru 101.1 ruthenium	45 Rh 102.9 rhodium	46 Pd 106.4 palladium	47 Ag 107.9 silver	48 Cd 112.4 cadmium	49 In 114.8 indium	50 Sn 118.7 tin	51 Sb 121.8 antimony	52 Te 127.6 tellurium	53 I 126.9 iodine	54 Xe 131.3 xenon

It is possible to convert grams to moles to units and back



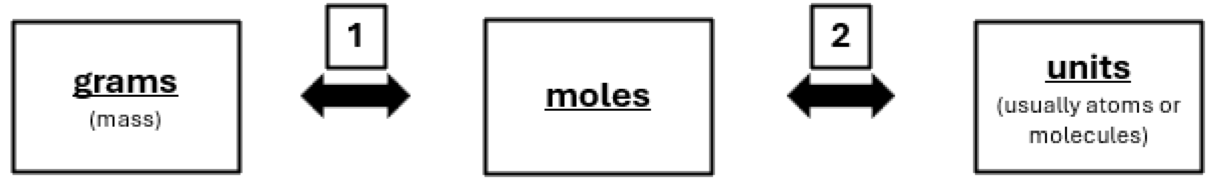
1. use grams per mole from the periodic table (i.e. H_2O is 18.016 grams = 1 mole or 18.016 g/mol)
2. 6.022×10^{23} units = 1 mol

Units = anything but usually molecules or atoms in this class

Check Your Learning

Beryllium is a light metal used to fabricate transparent X-ray windows for medical imaging instruments. How many moles of Be are in a thin-foil window weighing 3.24 g?

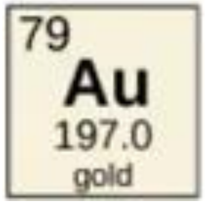
4
Be
9.012
beryllium

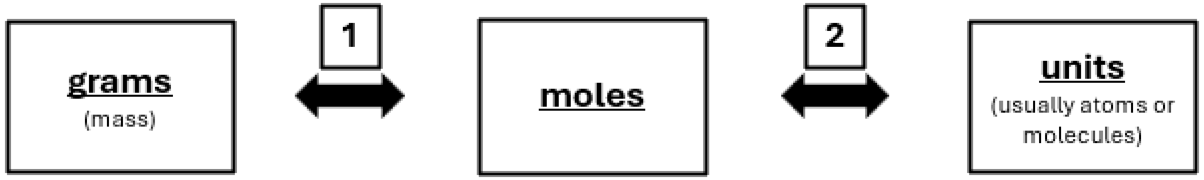


1. use grams per mole from the periodic table (i.e. H_2O is 18.016 grams = 1 mole or 18.016 g/mol)
2. 6.022×10^{23} units = 1 mol

Check Your Learning

What is the mass of 2.561 mol of gold?

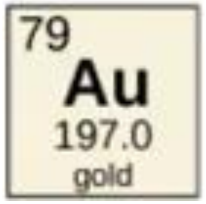


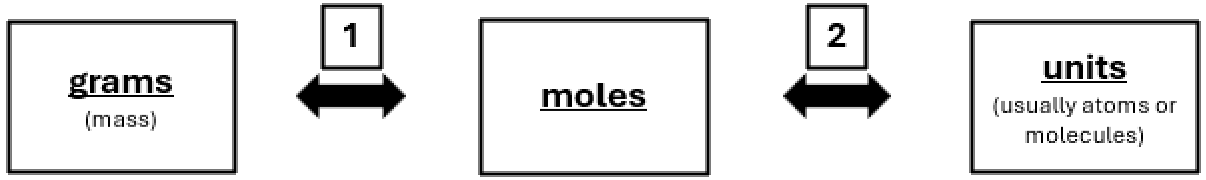


1. use grams per mole from the periodic table (i.e. H_2O is 18.016 grams = 1 mole or 18.016 g/mol)
2. 6.022 x 10^{23} units = 1 mol

Check Your Learning

A prospector panning for gold in a river collects 15.00 g of pure gold. How many Au atoms are in this quantity of gold?

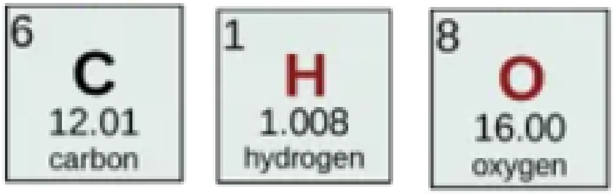


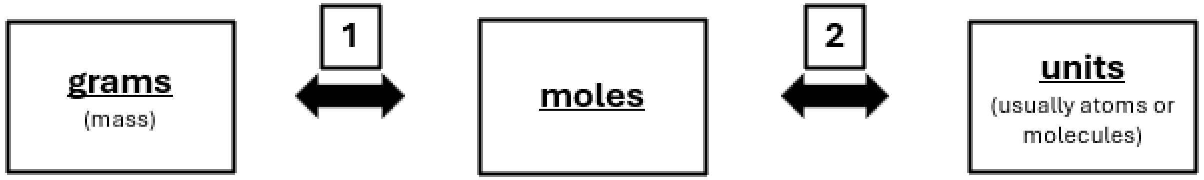


1. use grams per mole from the periodic table (i.e. H_2O is 18.016 grams = 1 mole or 18.016 g/mol)
2. 6.022 x 10^{23} units = 1 mol

Check Your Learning

How many moles of sucrose, $C_{12}H_{22}O_{11}$, are in a 25-g sample of sucrose?

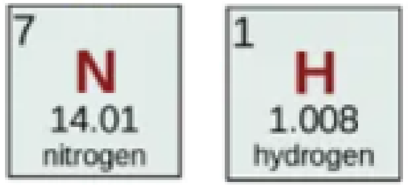


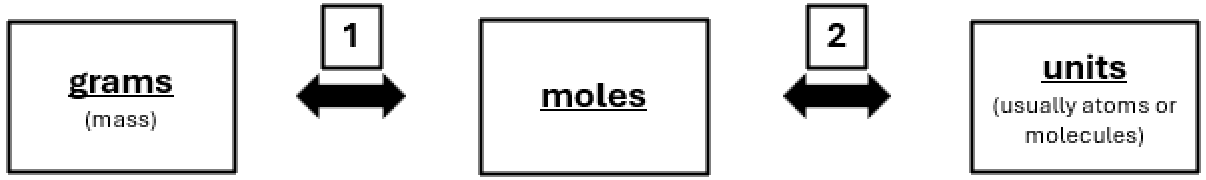


1. use grams per mole from the periodic table (i.e. H_2O is 18.016 grams = 1 mole or 18.016 g/mol)
2. 6.022 x 10^{23} units = 1 mol

Check Your Learning

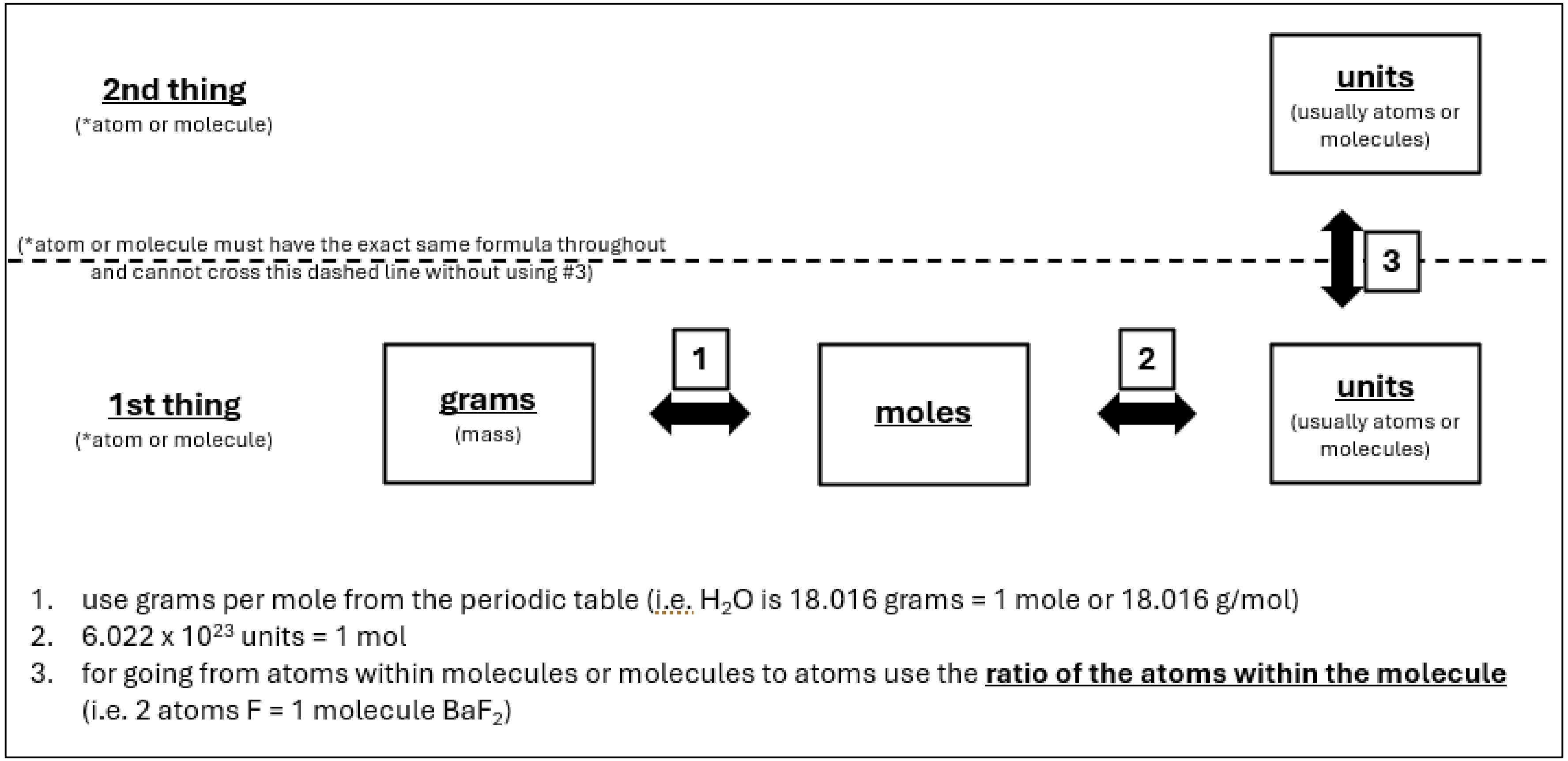
What is the mass of 0.443 mol of hydrazine, N_2H_4?





1. use grams per mole from the periodic table (i.e. H_2O is 18.016 grams = 1 mole or 18.016 g/mol)
2. 6.022 x 10^{23} units = 1 mol

You can make your own conversion rates from the ratio of atoms in the molecule (the mole ratio)



$$1\ molecule\ BaF_2 = 2\ atoms\ F$$

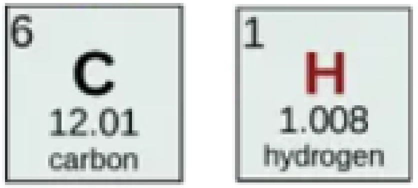
$$1\ molecule\ BaF_2 = 1\ atoms\ Ba$$

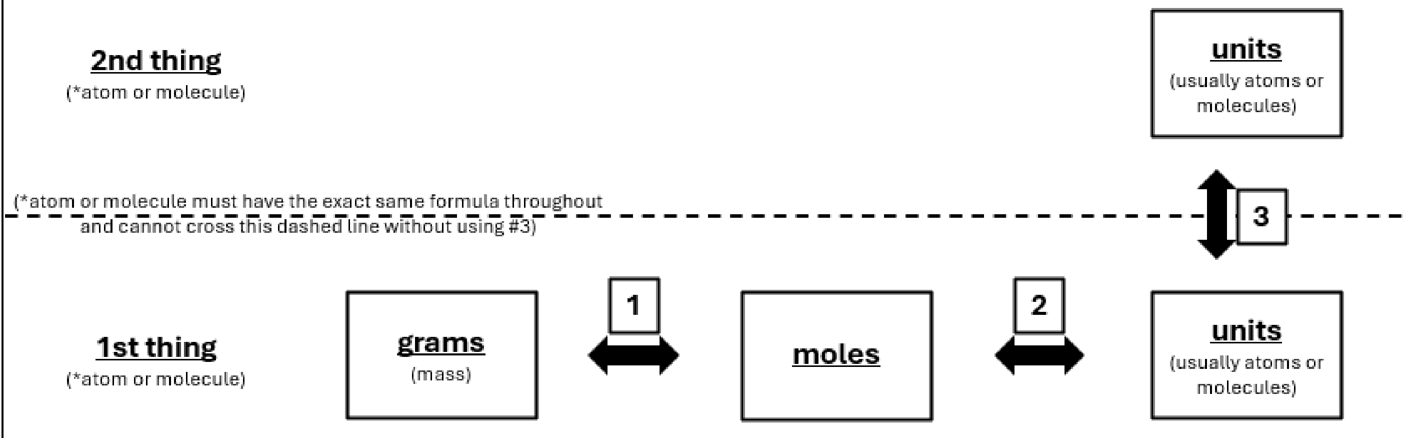
$$\frac{1\ molecule\ BaF_2}{2\ atoms\ F} \text{ or } \frac{2\ atoms\ F}{1\ molecule\ BaF_2}$$

$$\frac{1\ molecule\ BaF_2}{1\ atom\ Ba} \text{ or } \frac{1\ atoms\ Ba}{1\ molecule\ BaF_2}$$

Check Your Learning

How many C_4H_{10} molecules are contained in 9.213 g of this compound? How many hydrogen atoms?





1. use grams per mole from the periodic table (i.e. H_2O is 18.016 grams = 1 mole or 18.016 g/mol)
2. 6.022 x 10^{23} units = 1 mol
3. for going from atoms within molecules or molecules to atoms use the **ratio of the atoms within the molecule** (i.e. 2 atoms F = 1 molecule BaF_2)