Math evaluation:

solve for X $\quad 108X + 2Y = 520$ and $Y = 14X$

$$108X + 2(14X) = 520$$
$$108X + 28X = 520$$
$$136X = 520$$
$$X = 3.82$$

② Simplify: $(32XY^5)^3$ inferred 1

* distribute the n^3 term as multiplier into exponents

$$\underbrace{32^3}\ \underbrace{1\times3}\ \underbrace{5\times3}$$
$$32768x^3y^{15}$$

③ $100 = 4^x$ * use log rules to solve

$$\log 100 = x \log 4$$
$$X = \frac{\log 100}{\log 4} = \frac{2}{0.602} = 3.32$$

Chemistry is a quantitative Science: completely relies on quantities

- quantities are measured
- quantities represent a property and $\boxed{\text{MUST}}$ be compared to a standard to give it meaning

NUMBER UNIT

- Numbers are absolutely meaningless without a unit.
  - For example, I weigh 104.3, would you believe me?
  - but it's true, 104.3 Kg

1 Kg = 2.1758 pounds

104.3 Kg ... for every Kg I weigh 2.1758 Pounds

$$\underbrace{104.3\ \text{kg}}\ (2.1758\ \text{pounds}) = \underbrace{226.9\ \text{Pounds}}$$

Are these the same number? Of course not

But they do have the same meaning

OR

They ARE equal

- This example highlights the importance of Dim. Analysis

(4) Dimensional Analysis: Allows numbers to be transformed to reflect alternate units

Need a $\underbrace{\text{conversion Factor}}$

↳ a way to relate two units

· In the example above, 1 Kg = 2.1758 pounds is a conversion factor

How do you know that there are 12 donuts in a dozen?

· 1 dz = 12 donuts is a conversion factor that you are very accustomed to using.

But how do we use them ?!?

Set up the problem by writing out the number you WANT TO Convert

104.3 Kg

our goal is to cancel out Kg and be left with pounds

$$104.3\,\text{Kg}\underbrace{\left(\frac{\text{Pounds}}{\text{Kg}}\right)}$$

Kg is the denominator, so it will cancel with the Kg unit in 104.3 Kg

Now we need to put numbers with the units in the C.F.

$$\frac{1\,\text{Kg}}{\ } = \frac{2.1758\,\text{Pounds}}{\ }$$

stays with   stays with

$$104.3\,\cancel{\text{Kg}}\left(\frac{2.1758\,\text{Pounds}}{1\,\cancel{\text{Kg}}}\right)$$

104.3 kg = 226.9 Pounds

Another example:

The speed limit on I77 going home is 65 mph

Yep, this is a conversion factor!

65 miles = 1 hour

If you have 46 miles to your exit, how long will it take?

Approach: convert distance (miles) to time (hours)

Use 65 mph as the C.F.

units 1st

$$\frac{46\ \cancel{\text{miles}}}{} \left| \frac{1\ \text{hour}}{65\ \cancel{\text{miles}}} \right. = 0.707692\ldots\ \text{hours}$$

How will you know how many decimal places to use? Sig Figs!

Skill 1 → determining # of S.F.

1. non-zeroes are ALWAYS significant 12345 → 5 sig figs
2. Trailing zeroes are only significant IF after the decimal OR the decimal is clearly shown
3. A zero b/t non-zeroes is significant $\underbrace{40426}_{5\text{ SF}}0$ ← not significant
4. Leading zeroes are never significant 0426 → 3 SF ← not significant

14620 ← not significant (no decimal shown)

14620. → 5 S.F.

14620.00 7 S.F.

2. Addition/Subtraction w/ S.F.

- line up the decimals

$$
\begin{array}{r}
42.68 \\
+ \quad 1.46|3 \\
\hline
\underbrace{44.14}_{4\text{ S.F.}}|3
\end{array}
$$

← not significant

3. Multiplication/Division

- Easy → smallest number of S.F. wins

$\overset{3}{108.} * \overset{2}{042} = \underline{42}00$ only 2

If ambiguous, convert to Scientific notation

4200 w/ 2 SF = 4.2×10^3

4200 w/ 3 SF = 4.20×10^3

Back to units

Metric Prefixes ⇒ make life convenient

Tera	T	10^{12}
Giga	G	10^9
Mega	M	10^6
kilo	k	10^{+3}

milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

Å = angström = 10^{-10} meters

centi c 10^{-2}

Using the prefixes → JUST like any other conversion factor

1 km = 10^3 m

1 μm = 10^{-6} m

1 pm = 10^{-12} m

1 ALWAYS goes with prefix!

Convert 14 m → μm

$$\frac{14\,\text{m}}{} \bigg| \frac{1\ \mu\text{m}}{10^{-6}\ \text{m}} = 14 \times 10^6 = 1.4 \times 10^7\,\mu\text{m}$$

$14\,km \rightarrow \mu m$

$km \searrow m \nearrow \mu m$

No direct CF, So use 2 steps

$$\frac{14\,km}{} \left| \frac{10^{3}\,m}{1\,km} \right| \frac{1\,\mu m}{10^{-6}\,m} = 1.4 \times 10^{10}\,\mu m$$

Quick Refresher:

Remember that a number is meaningless w/o a unit

- we talked about how to convert between units using a very simple convention that focuses on units, NOT numbers!

A baker makes 44 donuts. How many boxes will he need if each box holds one dozen?

$$44 \text{ donuts} \left(\frac{1 \text{ dozen}}{12 \text{ donuts}}\right) = 3.67 \text{ dozen}$$

More involved example:

A dog whistle has a frequency of 23000 s^{-1}. What is the frequency in $days^{-1}$?

Conv. factors we need:

60 sec = 1 min

60 min = 1 hr

24 hrs = 1 day

Also, note that $s^{-1} = \frac{1}{sec}$ → so our number is $23{,}000 \frac{1}{sec}$

$$23{,}000 \frac{1}{sec} \cdot \frac{60 \text{ sec}}{1 \text{ min}} = 1{,}380{,}000 \frac{1}{min} \left(\frac{60 \text{ min}}{1 \text{ hr}}\right) = 82{,}800{,}000 \frac{1}{hr}$$

$$82{,}800{,}000 \frac{1}{hr} \left(\frac{24 \text{ hr}}{1 \text{ day}}\right) = 1{,}987{,}200{,}000 \frac{1}{day}$$

Inconvenient! Use scientific notation $1.9872 \times 10^9 \ day^{-1}$

... 2 billion times per day! Awesome

Also, pretty inconvenient to write each conversion separately, lets simplify

$$23{,}000 \frac{1}{\cancel{sec}} \left| \frac{60 \cancel{sec}}{1 \cancel{min}} \right| \frac{60 \cancel{min}}{1 \cancel{hr}} \left| \frac{24 \cancel{hr}}{1 \text{ day}} \right. = 1.9872 \times 10^{9} \text{ day}^{-1}$$

* this is faster + will save lots of time, but not essential

Using conversion factors to help understand something:

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

Density of gold is $19.32 \frac{g}{mL}$.

This means that 1mL of gold has a mass of exactly 19.32 g

1mL = 19.32g

this can be used as a conversion factor

If I drop 28.2 g of Au into a cylinder of H_2O, what volume change should I expect?

$$28.2 g \left| \frac{1 \text{ mL}}{19.32 g} \right. = 1.46 \text{ mL}$$

Try this: How much is that gold bar worth?

Value: 1 oz = \$1323 + 1 g = 0.035 oz

$$28.2 g \left| \frac{0.035 \text{ oz}}{1 \text{ g}} \right| \frac{1323 \$}{1 \text{ oz}} = \$1305.8$$

Converting in multiple dimensions

You can express the density of gold in $\frac{\text{pounds}}{\text{gallon}}$

1 pound = 453.592 g

1 gallon = 3785.41 mL

$$19.32 \frac{\cancel{g}}{\cancel{mL}} \left| \frac{1 \text{ pound}}{453.592 \cancel{g}} \right| \frac{3785.41 \cancel{mL}}{1 \text{ gallon}} = 161.23 \frac{\text{pounds}}{\text{gallon}}$$

* is this a different value? * NO these values are equivalent, just expressed in different units

Sometimes units are squared or cubed. These can be converted as well

Area = 

$= 12\,m \times 16\,m = 192\,m^2$

$m \times m = m^2$

To convert this to km^2, need to remember that $m^2 = m \times m$

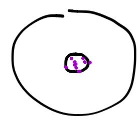
$$192\,m^2 = 192\,\cancel{m}\times\cancel{m}\,\Big|\,\frac{10^{-3}\,km}{1\,\cancel{m}}\,\Big|\,\frac{10^{-3}\,km}{1\,\cancel{m}} = 192\times10^{-6}\,km^2$$

<u>OR</u>

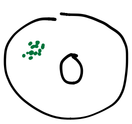
$$192\,m^2\left(\frac{10^{-3}\,km}{1\,m}\right)^2 = 192\times10^{-6}\,km^2 = 1.92\times10^{-4}\,km^2$$

<u>Measurements</u>

- Every instrument we use has a limit to which it can measure numbers
  - Accurately
  - Precision

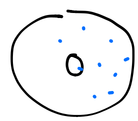


very accurate
very precise



high precision
low accuracy

high accuracy
low precision



poor accuracy
poor precision

- The same thought process can be extended to <u>ANY</u> instrument used to make a measurement.
  - A thermometer that is accurate but not precise is less reliable than one that is accurate + precise. The latter is even more reliable than something that is not accurate

this is the idea behind Significant Digits (Sig Figs)

- The number of digits that are meaningful depend on how confident we are in the method used to measure the number

25.0000 has 6 digits that are significant (we acknowledge error in the last digit.

25.0 only has 3 SF → error in the ∅

we don't deal much with the error aspect of SF in this class, but you do need to be comfortable with working w/ SF

Skill 1 → determining # of S.F.

1. non-zeroes are ALWAYS significant   12345 → 5 sig figs
2. Trailing zeroes are only significant IF a decimal is written OR the decimal is clearly shown
3. A zero b/t non-zeroes is significant $\underbrace{40426}_{5\,SF}0$ ← not significant
4. Leading zeroes are never significant   0426 → 3 SF
   ↑ not significant

1462**0** ← not significant (no decimal shown)

14620. → 5 S.F.

14620.00   7 S.F.

2. Addition/Subtraction w/ S.F.

- line up the decimals

$$\begin{array}{r} 42.68 \\ +\ \ 1.463 \\ \hline \underbrace{44.14}_{4\ S.F.}3 \end{array}$$

← not significant

3. Multiplication / Division

$\overset{3}{\widehat{100.}} * \overset{2}{\widehat{042}} = \underline{45}00$

only 2

- Easy → smallest number of S.F. wins

If ambiguous, convert to scientific notation

4200 w/ 2 SF = 4.2×10^3

4200 w/ 3 SF = 4.20×10^3

Back to units

Metric Prefixes ⇒ make life convenient

Tera	T	10^{12}	milli	m	10^{-3}	centi	c	10^{-2}
Giga	G	10^9	micro	μ	10^{-6}			
Mega	M	10^6	nano	n	10^{-9}			
kilo	k	10^{+3}	pico	p	10^{-12}			

Å = angström = 10^{-10} meters

using the prefixes → JUST like any other conversion factor

$1\ km = 10^3\ m$

$1\ \mu m = 10^{-6}\ m$

$1\ pm = 10^{-12}\ m$

1 ALWAYS goes with prefix!

convert $14\ m \rightarrow \mu m$

$\frac{14\ m}{} \cdot \frac{1\ \mu m}{10^{-6}\ m} = 14 \times 10^6 = 1.4 \times 10^7\ \mu m$

$14\ km \rightarrow \mu m$

$km \searrow m \nearrow \mu m$

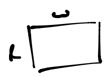
No direct CF, so use 2 steps

$\frac{14\ km}{} \cdot \frac{10^3\ m}{1\ km} \cdot \frac{1\ \mu m}{10^{-6}\ m} = 1.4 \times 10^{10}\ \mu m$

STANDARD unit Convention → SI (System International)

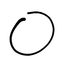
- distance/length → m
- time → s
- mass → kg
- Temperature → K
- Amount of Substance → mol

- Other units are derived from these:
  - Area



$A = l \times w = m \times m = m^2$

$A = \frac{1}{2} b h = m \times m = m^2$



$A = \pi r^2 = m \times m = m^2$

Volume: Box $= lwh = m \times m \times m = m^3$

Sphere $= \frac{4}{3} \pi r^3 = m^3$

cylinder $\pi r^2 h = m^2 \, m = m^3$

SI unit of volume is NOT L or mL

How big is $1\,m^3$? → convert to L

* important convention ⟹ $1\,mL = 1\,cm^3$ *

$$1\,m^3 \equiv \frac{1\,m \times m \times m}{} \left| \frac{1\,cm}{10^{-2}\,m} \right| \frac{1\,cm}{10^{-2}\,m} \left| \frac{1\,cm}{10^{-2}\,m} \right.$$

$$1\,m^3 = 1 \times 10^6\,cm^3 \left| \frac{1\,mL}{1\,cm^3} \right| \frac{10^{-3}\,L}{1\,mL} = 1 \times 10^3\,L$$

$1\,m^3 = 1000\,L$

strategy: $m^3 \to cm^3$

$cm^3 \to mL$

$mL \to L$

BUT remember to account for ALL 3 units of meters