Chem 101 workshops

1. Significant figures
2. Scientific notation
3. Calculations involving powers of 10

1. To find out more about significant figures try the web tutorial at
   http://www.maths.mq.edu.au/numeracy

Click on tutorial and away you go!

Summary of points

When looking at significant figures, it is easiest to see how many there are when the number is given in scientific notation.

As a general rule zeros to the left of a number are not significant.

Zeros within the number and to the right of the number are counted as significant.

Eg.	0.00039	has	2 significant figures
	3.004	has	4 significant figures
	125.00	has	5 significant figures.

Difficulties with significant figures generally arise when we have zeros to the right of the number.

In the above example 125.00 has 5 significant figures
125 would have 3.

If we wrote both of these number in scientific notation, the difference becomes clear, more on that later

Using 125.00 and 125 as an example.

Suppose the above 2 amounts were money.
Then 125.00 represents an amount to the nearest cent
whereas 125 represents an amount to the nearest dolla

Multiplicat e divisio of ~~significant~~ numbers e significant figures

* When multiplying or dividing numbers, our answer must have the same number of significant figures as the smallest number in our question.

for example (1) $1.03 \times 2 = 2.06$

but 1.03 has 3 significant figures
2 only has 1 significant figure

So the actual answer should only have 1 significant figu
ie The answer is 2.

$1.03 \times 2 = 2$ — when using appropriate number of significant figures.

(2) $\frac{1.39 \times 2.14}{6.9} = .43$

My calculator tells me the answer is .43110144 9
but looking at the question I have 2 numbers with 3 significant figures and 1 with 2 significant figures.
So my answer should have 2 significant figures.

Adding and subtracting

When adding and subtracting numbers when you are required to take into account significant figures, you dont count the number of significant figures but go with the least precise number to tell you significance.

NB The least precise number will be the one whose last significant figure is the most to the left when the numbers are written out of scientific notation.

eg 1

$$\begin{array}{r} 1.39 \; + \\ 2.1 \\ 10.36 \\ 4.02 \\ \underline{13.21} \\ 31.08 \end{array}$$

Notice that the number whose last significant figure is the most to the left is the 2.1

All the others have 2 significant decimal places.

Our answer should match the 2.1 and only have 1 significant decimal place.

Rounding 31.08 to 1 decimal place gives us 31.1 as our answer.

eg 2

$$\begin{array}{r} 14.04 \; - \\ \underline{3.0} \\ 11.04 \end{array}$$

Notice that the 3.0 has the last significant figure in the left most place which is the first decimal place. Our answer should match this so rounding gives us an answer of 11.0.

2 Scientific Notation.

Scientific notation is a way of writing numbers that makes the number of significant figures completely clear.

A number is in scientific notation when written in the following way:

* exactly 1 digit to the left of the decimal place – this digit should not be a zero. but come from the numbers 1 to 9.

* this figure is then multiplied by the appropriate power of 10 to give it the correct size

Eg 1.59×10^3 is written in scientific nota

13.61×10^4 is not

0.59×10^2 is not.

All numbers that we write are written is such a way as to give particular meaning to the digits.

We all know the difference between

50.00 and 00.50

from our dealing with money. What makes the difference is the position of the 5 relative to the decimal point. The position represents the digits place value.

50.00 has a 5 in the 10's column

00.50 has a 5 in the $\frac{1}{10}$'s column.

multiplying a number by 10 shifts everything to the left by one column.

so $57.60 \times 10 = 576.0$

and dividing by 10 (or multiplying by $\frac{1}{10}$) shifts everything to the right by 1 column.

so $57.60 \div 10$

$= 57.60 \times \frac{1}{10}$

$= 5.760$

We can take advantage of this when using scientific notation.

But first we need the following information

$\frac{1}{10} = 10^{-1}$	$10 = 10^{1}$
$\frac{1}{100} = \frac{1}{10^2} = 10^{-2}$	$100 = 10 \times 10 = 10^{2}$
$\frac{1}{1000} = \frac{1}{10^3} = 10^{-3}$	$1000 = 10 \times 10 \times 10 = 10^{3}$
etc.	etc

DO YOU SEE THE PATTERNS.

To put a number into scientific notation

we need to work out how many columns we need to shift by (and whether the shift is left or right) to get just 1 digit to the left of the decimal point.

$$59704.6 = 5.97046 \times 10^4$$

Since we need to shift by 4 columns.

$$0.0039 = 3.9 \times 10^{-3}$$

Since we needed to shift by 3 columns.

to check 5.97046×10^4

$= 5.97046 \times 10 \times 10 \times 10 \times 10$

each $\times 10$ says shift 1 column to left

$= 59.7046 \times 10 \times 10 \times 10$

$= 597.046 \times 10 \times 10$

$= 5970.46 \times 10$

$= 59704.6$

Similarly $3.9 \times 10^{-3} = 3.9 \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10}$

$= .39 \times \frac{1}{10} \times \frac{1}{10}$

3 column shifts.

$= .039 \times \frac{1}{10}$

$= .0039$

A few more examples.

$$4.12 \times 10^{-2} = .0412.$$

A quick way to do this is to draw he following shifting he decimal pt. As he columns of number shift right, he decimal pt effectively shifts left so

$$\cdot\underbrace{\ \ }_{2}\underbrace{4}_{1}.12$$ and then any empty valleys are filled wih zeros so

$$\cdot\underbrace{\ \ }_{2}\underbrace{4}_{1}.12 \quad \text{becomes} \quad \cdot\underbrace{0}_{2}\underbrace{4}_{1}.12$$

and finally $.0412$

$$2.19 \times 10^{5} = 2.\underbrace{1}_{1}\underbrace{9}_{2}\underbrace{\ }_{3}\underbrace{\ }_{4}\underbrace{\ }_{5}\cdot$$

$$= 219000\cdot$$

$$= 219000.$$

$$325.4 = 325.4 = 3.254 \times 10^{2}$$

$$.000056 = 5.6 \times 10^{-5}$$

$$3496000000. = 3.496000000 \times 10^{9}$$

with the 10 significant figures.

$$3.496 \times 10^{8} = 349600000$$

wih only 4 significant figures.

The last example shows how scientific notation helps us deal with significant zeros.

Suppose I have exactly 61,000 dollars

& my friend has roughly 61,000 dollars to the nearest thousand dollars.

How can we tell the difference between these 2 amounts.

Difficult to do when they are written in normal notation but if I were to write both these figures in scientific notation we would get the following

I have 6.1000×10^4 dollars

whereas my friend has 6.1×10^4 dollars

Now you can tell whose measurement is more precise even though we still can't tell who has more money!

(3) Calculations involving powers of 10

There are some rules which are helpful.

notice that if I have $10^2 \times 10^3$

$$= (10 \times 10) \times (10 \times 10 \times 10)$$

$$= 10 \times 10 \times 10 \times 10 \times 10$$

$$= 10^5$$

You can see why the new power 5 is just 2+3

This is actually always true so

$$10^{a} \times 10^{b} = 10^{a+b}$$

even if one of them is negative.

(If you want to understand this further come & see someone at the Numeracy Centre)

Another thing we have taken for granted since we were little kids is that

$$3 \times 2 = 2 \times 3 \quad \text{or in general}$$

$$a \times b = b \times a$$

Using these two helpful facts lets do some calculations involving powers of 10.

(1) $2.31 \times 10^{4} \times 1.6 \times 10^{2} = 2.31 \times 1.6 \times 10^{4} \times 10^{2}$
$= 2.31 \times 1.6 \times 10^{6}$
$= 3.696 \times 10^{6}$

but 1.6 only has 2 significant figures so rounding gives us
$= 3.7 \times 10^{6}$

(2) $4.1 \times 10^{3} \times 2 \times 10^{-2} = 4.1 \times 2 \times 10^{3} \times 10^{-2}$
$= 8.1 \times 10^{1}$
$= 8 \times 10^{1}$ (significant figures)

3 $3.16 \times 10^{-5} \times 2.41 \times 10^{3}$

$= 3.16 \times 2.41 \times 10^{-5} \times 10^{3}$

$(-5+3=-2)$

$= 3.16 \times 2.41 \times 10^{-2}$

$= 7.6156 \times 10^{-2}$

significant figures

$= 7.62 \times 10^{-2}$

4 $1.2 \times 10^{-5} \times 4.0 \times 10^{-2}$

$= 1.2 \times 4.0 \times 10^{-5} \times 10^{-2}$

$= 4.8 \times 10^{-7}$ $(-5+-2) = -$

$= 4.8 \times 10^{-7}$

What about dividing

Another rule $\dfrac{10^{x}}{10^{y}} = 10^{x-y}$

so eg 1 $\dfrac{10^{5}}{10^{3}} = 10^{2}$ since $5-3=2$

2 $\dfrac{10^{-3}}{10^{+1}} = 10^{-4}$ since $-3-1=-4$

3 $\dfrac{10^{4}}{10^{-2}} = 10^{6}$ since $4-(-2)=6$

So now we can do the following examples.

1. $$\frac{2.39 \times 10^4}{1.6 \times 10^2} = \frac{2.39}{1.6} \times \frac{10^4}{10^2}$$

$$= \frac{2.39}{1.6} \times 10^{4-2}$$

$$= \frac{2.39}{1.6} \times 10^{2}$$

$$= 1.49375 \times 10^2$$

$$\doteq 1.5 \times 10^2$$ significant figures.

2. $$\frac{5.69 \times 10^3}{10^{-2}} = \frac{5.69}{1} \times \frac{10^3}{10^{-2}}$$

$$= 5.69 \times 10^{3-(-2)}$$

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

$$= 5.69 \times 10^5$$

$$\doteq 6 \times 10^5$$ since

10^{-2} only has 1 significant figure

3. $$\frac{2.4 \times 10^{-2}}{1.2 \times 10^{-6}} = \frac{2.4}{1.2} \times \frac{10^{-2}}{10^{-6}}$$

$$= 2.0 \times 10^{-2-(-6)}$$

$$= 2.0 \times 10^4$$

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Unit of measurement

basic standard unit include

metre	-	m
litre	-	L
mole	-	mol
watt	-	W
byte	-	b

Standard prefixes	symbol	1 metre x
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
		1
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

converting units is largely just keeping track of multiplication by the correct power of 10

To go down the scale from something bigger to something smaller you multiply by an appropriate positive power of 10

so eg. If you have

$.5$ of a metre

and you want to know how many mm there are

$$.5 \times 10^3 \text{ mm} = .5 \text{ m}$$

since you are going down 1 step of the scale.

To go up the scale from a smaller unit of measurement to a bigger one you have to divide by an appropriate positive power of 10 (or alternatively this is the same as multiplying by a negative power of 10)

an example $100\,\mu g = ?$ grams

micro to no prefix is going up 2 steps so

$\cancel{100} \times 10^{-3} \times 10^{-3}$

$$100\,\mu g = 100 \times 10^{-3} \times 10^{-3} \text{ grams}$$

$$\overset{100}{\overset{\shortparallel}{100\ \mu g}} = 1.00 \times 10^{2} \times 10^{-3} \times 10^{-3} \text{ grams}$$

$$= 1.00 \times 10^{2-3-3}$$

$$= 1.00 \times 10^{-4} \text{ grams.}$$

$$= 1.00 \times 10^{-4} \text{ g}$$

Some more examples.

1. $.56$ Tbytes $=$? bytes.

$.56$ Tbytes $= 5.6 \times 10^{-1}$ Tbytes (scientific notation)

1 Tbyte $= 1 \times 10^{3} \times 10^{3} \times 10^{3} \times 10^{3}$ bytes.
$= 1 \times 10^{12}$ bytes

so 5.6×10^{-1} Tbytes $= 5.6 \times 10^{-1} \times 1 \times 10^{12}$ bytes

$= 5.6 \times 10^{-1} \times 10^{12}$
$= 5.6 \times 10^{11}$ bytes

2. How many grams are there in:

(a) $.69$ kg $= 6.9 \times 10^{-1}$ kg — down scale by 1 step.

$= 6.9 \times 10^{-1} \times 10^{3}$ g

$= 6.9 \times 10^{2}$ g

(b) $71.3\ kg = 7.13 \times 10^1\ kg$ ↓ 1 step

$= 7.13 \times 10^1 \times 10^3\ g$

$= 7.13 \times 10^4\ g$

(c) $639\ mg = 6.39 \times 10^2\ mg$ up 1 step

$= 6.39 \times 10^2 \times 10^{-3}\ g$ so $\times 10^{-3}$ (or $\div 10^3$)

$= 6.39 \times 10^{-1}\ g$

(d) $18\ mg = 1.8 \times 10^1\ mg$

$= 1.8 \times 10^1 \times 10^{-3}\ g$

$= 1.8 \times 10^{-2}\ g$

There are 2 more things I haven't talked about yet. , one of them is centimetres.

We dont usually use the prefix centi for anything except distance measurements and it doesn't fit in the nice pattern we got on page 1.

a centimetre $= 1 \times 10^{-2}$ of a metre.
a metre $= 1 \times 10^2$ cm.
i.e. 100 centimetres = 1 metre
1 centimetre $= \frac{1}{100}$ metre.

eg. 2 How many centimetres are there in

(a) $2.93\ m = 2.93 \times 10^2\ cm$

$= 2.93 \times 10^2\ cm.$

(b) $.43\ m =$