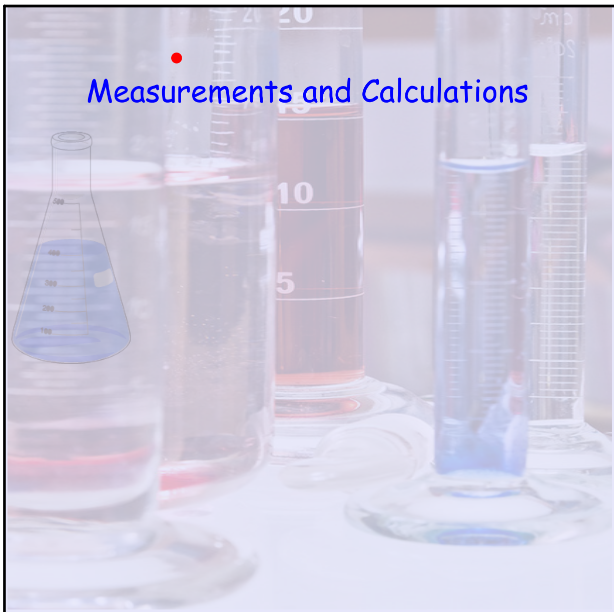
Measurements and Calculations



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Sep 23-9:11 PM

Topic I: The metric system

Objectives:
1. Learn why the metric system was devised
2. Be able to name the standards for measurements
3. List and use the metric prefixes
4. Be able to convert from one metric unit to another

Topic II: Scientific Notation

Objectives:
1. write numbers in both standard and in scientific notation
2. be able to perform basic arithmetic operations with scientific notation

Sep 23-9:22 PM

Topic III: Significant figures

Objectives: 1. Be able to determine the number of significant figures in a given measurement.

2. Be able to predict the number of significant figures in the result of required calculations

3. Be able to relate the measurements taken in the lab, to the significant figures in calculations

Topic IV : Accuracy and Precision

Topic V : Inverse and direct proportions

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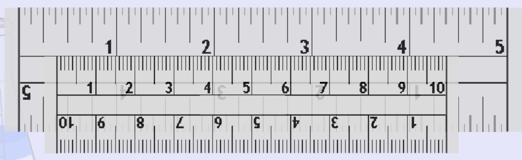
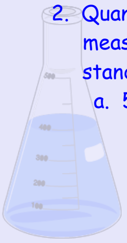
The metric system
(International system of units)



Sep 23-10:05 PM

I. Chemistry Involves Measuring and Calculating

1. Qualitative –
   describes a property without measurements.
   a. hot, humid, fast, slow, heavy etc.
2. Quantitative –
   measuring and describing a property by a number of standard units.
   a. 5 kilograms, 15 meters, etc.



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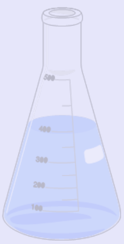
Three Requirements of a Measurement



1. knowledge of property to be measured.
2. a standard to compare our measure
3. a method of making the measurement.
   equipment
   procedure

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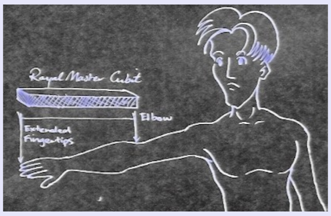
Some history of measurements:



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Length: the distance between two points

First standardized measurements were recorded in the ancient Mediterranean culture.

Based on body parts

fOR EXAMPLE: the length from elbow to outstretched fingertips: one cubit/

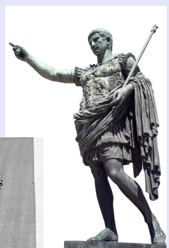
Sep 23-10:49 PM

The foot: legend has it that the greeks designated the "foot" as the actual size of Hercules's foot...

as retrieved from:
http://ellerbruch.nmu.edu/CS255/JONIEMI/metricsyst

Sep 26-2:12 PM

The yard...
the distance from the outstretched finger tips to the chin...



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but , whose chin and arm- the reigning King? yours? mine?

This system became confusing very quickly.

I t was clear, as the age of enlightenment progressed and more and more measurements were being taken, that a more efficient and logical system was needed.
we needed:

*standards that were common to all.
*easily learned and used

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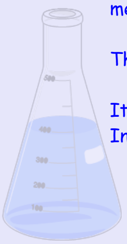


The French devised the first standardized system of measurements: Metric System

This was in the 1790's

It wasn't until the 1960's that it evolved to the International System of Units that we use today.

Sep 26-2:29 PM

The first standard for the meter:

1/10 000 000 of the distance from the north pole to the equator.

this seems like it should be no problem, but countries argued over whic meridian should be used to make the measurement!

Sep 26-2:31 PM

Modern Standards for fundamental measurements:

ength (m): distance between 2 points

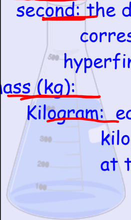
meter: The meter is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458s

me (s):

second: the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the Cs-133 atom

ass (kg):

Kilogram: equal to the mass of the international prototype of the kilogram, which is a cylinder of iridium-platinum alloy kept at the International Bureau of Weights and Measures .



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amount (mol):
mole: 1. The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12; its symbol is

2. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.

Temperature (K):
The kelvin : unit of thermodynamic temperature, the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.

Sep 26-2:46 PM

Any system of measurements has divisions- parts of the whole have different names-

The Imperial or British system has different methods of dividing the whole depending on what quantity we are measuring:

Length- inches, 12 inches in one foot, 3 feet in one yard, 5280 feet in one mile...

Volume: ounces; 8 ounces in a cup, 16 ounces in a pint, 2 pints in a quart, 4 quarts in a gallon..

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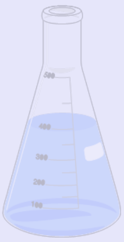
So, how do we use the metric system?



First: The divisions are all based on powers of 10
Second: each power is given a prefix
third: These prefixes do not change from one property to another!

We use the base units and add a prefix

nanometer — nano = 10^{-9}

centimeter — centi = 10^{-2}

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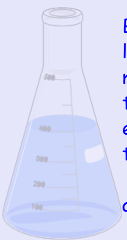
Table 1. SI base units



Base quantity	SI base unit (no prefix) Name	Symbol
length	meter	m
mass	gram	g
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

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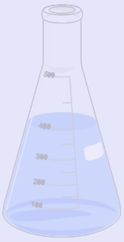

$39.33\,Kg = 39330\,g$

10^3 10^0

$$\frac{10^3}{10^0} = 10^{(3-0)} = 10^3$$

Sep 19-8:06 AM

Table SI prefixes

Factor	Name	Symbol	Factor	Name	Symbol
10^{24}	yotta	Y	10^{-1}	deci	d
10^{21}	zetta	Z	10^{-2}	centi	c
10^{18}	exa	E	10^{-3}	milli	m
10^{15}	peta	P	10^{-6}	micro	µ
10^{12}	tera	T	10^{-9}	nano	n
10^{9}	giga	G	10^{-12}	pico	p
10^{6}	mega	M	10^{-15}	femto	f
10^{3}	kilo	k	10^{-18}	atto	a
10^{2}	hecto	h	10^{-21}	zepto	z
10^{1}	deka	da			

Sep 26-3:24 PM

How many kg in one mg?
determine conversion factors:
1000 g = 1 kg and 1 kg = 1000g
giving us:

$\frac{1000g}{1\ kg}$ and $\frac{1kg}{1000\ g}$

1 gram = 1000 milligram
1000 milligram = 1 gram
giving us

$\frac{1\ g}{1000\ mg}$ and $\frac{1000\ mg}{1g}$

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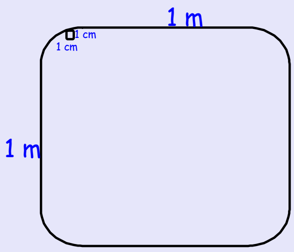
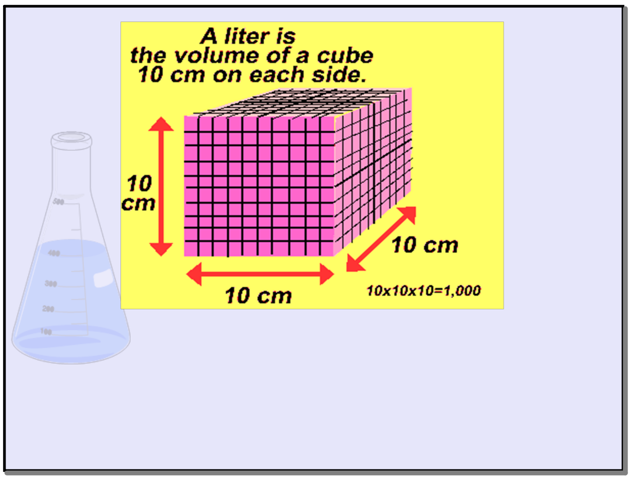
converting area:

convert $1m^2$ to cm^2



Each side must be converted:
$1m^2 \times 100cm/m \times 100cm/m = 10000\ cm^2$

Sep 26-4:02 PM



Sep 26-10:03 PM

SIGNIFICANT DIGITS

Sep 26-3:35 PM

There are two kinds of numbers in the world:

* exact:
  > example: There are exactly 12 eggs in a dozen.
  > example: There are exactly 24 students in the room
* inexact numbers:
  > example: any measurement.
  If I quickly measure the width of a piece of notebook paper, I might get 220 mm
  If I am more careful, I might get 216 mm .
  An even more careful measurement, or one with a more detailed metric ruler might give a measurement of 215.6 mm

Sep 23-10:49 PM

Each of the preceding measurements reflect the care and detail of the measuring equipment and technique.

We call the numbers in inexact measurements "significant figures."

significant ≠ important

Sep 23-10:55 PM

- the number of significant figures is critical.
- number of significant figures is the number of digits believed to be correct by the person doing the measuring.
 It includes one estimated digit.

The last reported digit is the estimated digit.

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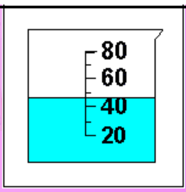
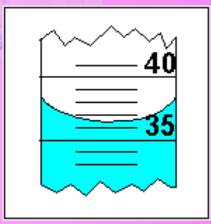


The smallest division is 10 mL, so we can read the volume to ±1/10 of 10 mL or ±1 mL. The volume we read from the beaker has a reading error of ±1 mL.

Read this volume measurement

Sep 23-11:00 PM



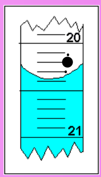
now this one:
What is the smallest division?
so we can estimate to the ± .1mL

Sep 23-11:01 PM

Accuracy :Closeness of a measurement to the accepted value

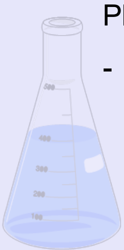
Precision: refers how closely grouped repeated measurements are to one another

Sep 19-8:25 AM



and this?

Sep 23-11:02 PM



report ALL #'s read right off equipment

Plus

- one more estimated digit.

Sep 22-9:48 AM

When you report a measurement,
You report every known digit, and
one estimated.

What about another person's measurement?

Sep 23-11:07 PM

When determining how many significant digits are in
a measurement you are reading, we have rules:

1. All nonzero digits are significant
988: 3 significant digits   929

2. All zeros between significant digits are significant: 909
90009   909: 3 significant digits

3. All zeros at the beginning of a number are not significant:
00.023   2 significant digits

4. All zeros at the end of a number, but before the decimal are not
significant
35400   3 significant figures, not 5

5. a zero at the end of a number AND to the right of a decimal point
is significant
354.00 5 significant figures

Sep 26-8:44 PM

Scientific Notation

Sep 26-9:23 PM

Scientific Notation is a way to represent numbers that are very large, and very small, easily.

0.0000000056 can be written as: 5.6×10^{9}

46600000000 can be written as 4.66×10^{10}

Sep 26-9:26 PM

Scientific notation has a strict format.

Numbers are written :

- $m \times 10^{n}$

m is the coefficient

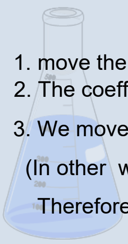
n is the exponent

where $1 \leq m < 10$

and n is any integer.

if n is negative, the number is less than one, not negative!

Sep 26-3:00 PM



Changing numbers from standard notation to scientific notation

convert 765 760 000 000 to scientific notation

(Remember, the decimal is at the end of the final zero.)

1. move the decimal until there is a number between 1 and 10
2. The coefficient will read: 7.6576 (don't keep the zeros)
3. We moved the decimal 11 places to the left.

(In other words, we divided by 10^{11}.)

Therefore, we need to multiply the coefficient by 10^{11},

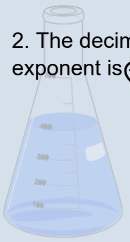
Answer equals 7.6576×10^{11}

Sep 26-9:50 PM

Change 0.000000902 to scientific notation

1. determine "m"

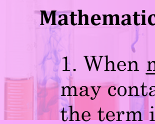
The coefficient will be 9.02



2. The decimal moves seven spaces to the right, so the exponent is -7.

Answer equals 9.02×10^{-7}

Sep 26-10:04 PM



Mathematical operations, and significant digits

1. When multiplying and dividing , the answer may contain only as many significant digits and the term in the original problem that contains the fewest.

3.2 x 5.45 = 17.44

but 3.2 only has 2 significant digits,
so our answer may only have 2 significant digits.

round: 17.44 to

Sep 26-8:54 PM

Multiplying in Scientific notation

1. Multiply the coefficients
2. Add the powers of 10

example: $(3.5 \times 10^7)(4.56 \times 10^4)$

$(3.5 \times 4.56)(10^{7+4}) = 15.96 \times 10^{11}$

correct the coefficient so that it is a number between 1 and 10

1.596

correct the exponent

10^{12}

apply significant figure rules

1.6×10^{12}

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Dividing in Scientific notation

1. divide the coefficients
2. subtract the exponents
3. correct the coefficients to be a number between 1 and 10
4. change the exponent to correct for the change in coefficient
5. apply sig fig rules

$5.23 \times 10^{-3} \div 6.44 \times 10^4$

$= 0.8121 \times 10^{-7}$ $(-3-4= -7)$

$= 8.12 \times 10^{-8}$ (mult .8 by 10 so divide 10^{-7} by 10)

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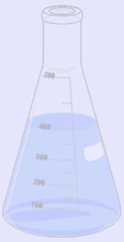


Oct 6-7:35 AM

Adding / Subtracting and significant Digits

2. When adding and subtracting, decimal places are used to determine the number of significant digits.

a. Put the terms in columnar form

b. add or subtract as directed.

c. the answer can only show as many decimal places as the measurement having the fewest places.

When we add 3.76 g + 14.83 g + 2.1 g = ?

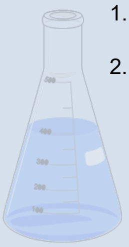
3.76 g
14.83 g
+ 2.1 g
20.69 g

round to the tenths place 20.7g

Sep 26-9:09 PM

Adding and subtracting in ScientificNotation

All exponents must be the same!



1. If they are: add the coefficients and
2. keep the common exponent.

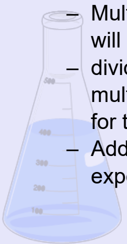
$3 \cdot 10^3 + 4 \cdot 10^3$

$7 \cdot 10^3$

example:

$6.2 \times 10^3 + 2.8 \times 10^3 = 9.0 \times 10^3$

Sep 27-2:21 PM



2. If they are not, you will need to change exponents so that they match
   - Choose the greatest exponent
   - Multiply all other exponents by a power of ten that will make them equal to the greatest power
   - divide your coefficients by what ever you multiplied the power of ten by in order to correct for the change.
   - Add the new coefficients and keep the greatest exponent as your common exponent.

Sep 24-9:17 AM

Example:

$(3.456 \times 10^{-2}) + (2.37 \times 10^{-4}) + (5.778 \times 10^{-3}) = ?$

$2.37 \cdot 10^{-4} \neq 2.37 \cdot 10^{-2}$

exponent of greatest value: -2

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

$10^{-4} \times 100 = 10^{-2}$

If we multiply the 10^n by something, we have to divide the coefficient by the same amount: $(3.456 \times 10^{-2}) + (2.37 \div 100 \times 10^{-4} \times 100) + (5.778 \div 10 \times 10^{-3} \times 10)$

$3.456 \times 10^{-2} + 0.0237 \times 10^{-2} + 0.5778 \times 10^{-2}$

$= 4.0575 \times 10^{-2}$

$= 4.06 \times 10^{-2}$

Sep 27-5:20 PM

Title: Finding the Density of Irregular Objects

Purpose:

1. Investigate the property of density
2. calculate the density of irregular objects using a direct method
3. Calculate the density using a graphical method
4. Use significant figures to reflect the equipment used.

Background Information : The density of any substance is defined as the amount of matter in a particular volume. We calculate this using the following equation:

$$D = \frac{M}{V}$$

The units are g/mL or g/c.c. 3.

Nov 3-8:17 PM

Materials:

triple beam balance

100 mL graduated cylinder

water

metal shot

paper towling

beaker

Procedure:

1. Find the mass of the empty beaker. Record.

Triple Balance looked dirty

2. Add the metal shot to the empty beaker and remass. Record.

3. Put about 5.0 mL of water in the graduated cylinder and then record the actual amount to the correct number of significant figures.

4. Add the metal shot to the water and record the new volume.

5. Repeat steps 1-4 for 2 more samples of metal shot.

4.

Nov 3-8:27 PM

Data:

	trial 1	trial 2	trial 3	trial 4
mass empty beaker (g)	61.13	50.61	49.62	48.93
mass beaker + shot (g)	88.41	95.50	85.66	111.2 109.58
mass shot (g)	27.28	45.89	36.04	60.65
volume before adding shot (mL)	62.50	54.0	52.0	55.0
volume after adding metal shot(mL)	69.1	65.0	60.5	68.5
volume of shot (mL)	6.6	11.0	8.5	13.5

Nov 3-8:35 PM

Calculations

1a.Calculation of mass of shot:

Mass of beaker + shot - mass of empty beaker = mass of metal shot

Trial 1 88.41g - 61.13g = 27.28 g

Trial 2 96.50g - 50.61g= 45.89g

trial 3 85.66g - 49.62g = 36.04 g

trial 4 109.58g - 48.93g = 60.65g

2a. Calculation of volume:

Volume of beaker + shot - volume of empty beaker =

volume of metal shot

Trial 1 69.10mL -62.5 mL = 6.6 mL

Trial 2 65.0mL - 54.0mL = 11.0 mL

trial 3 60.0 mL - 52.0mL = 8.5 mL

trial 4 68.5mL- 55.0 mL = 13.5 mL

Nov 3-8:43 PM

3a Calculating the density

$$D = \frac{M}{V}$$

Trial one: 27.28g/6.6 mL =4.1g/mL

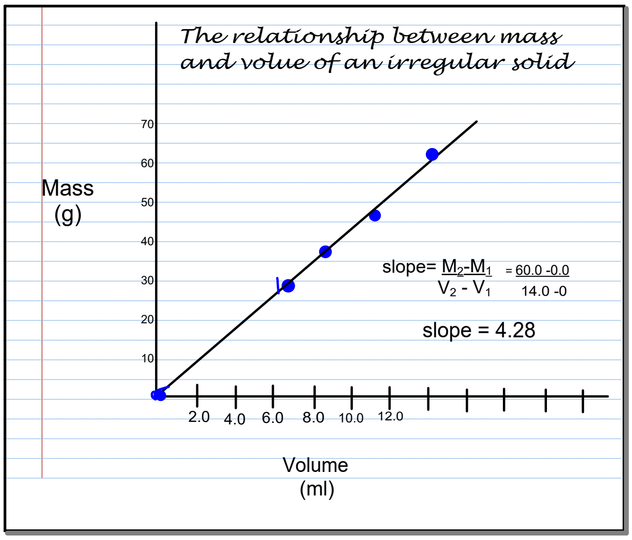
Trial 2: 45.89g/11.0 mL = 4.17g/mL

Trial 3 : 36.04 g/ 8.5 mL = 4.2 g/mL

Trial 4 : 60.65 g/ 13.5mL = 4.49 g/mL

average density for all 4 trials: 4.25 g/ml

Nov 4-10:36 AM



Nov 3-8:49 PM

The slope represents denisty and is constant.

Conclusion

The identity of the metal shot used: zinc

The accepted value for the density of zinc: 7.14 g/mL

My average density calculation: 4.25 g/mL

Density using the slope ofthe line: 4.28 g/mL

Error analysis

% error: $\left(\frac{\text{accepted value- calculated}}{\text{accepted}} \times 100\%\right)$

for calculated vs accepted

$= \frac{7.14 \text{ g/mL} - 4.25 \text{ g/mL}}{7.14\text{g/mL}} \times 100\% = 40.5\%$

for slope vs calculated

$\frac{4.28-4.25}{4.28} \times 100\% = 0.70\%$

Nov 3-8:55 PM

for my trial vs the group average

$$\frac{4.49-4.25}{4.25} \times 100\% = 5.6\%$$

Qualitative error analysis

how could this have been improved, where did sources of error occur.

Overall, I felt that we were following the directions well and was surprised to find that our values were 40% different than the accepted value for the density of zinc.

Reasons for this may be:

1. We did not bring our eyes to the level of the water in the graduated cylinder. Instead, we looked down at an angle with the surface of the water.

2. Not all in our group recorded the mass to enough significant figures.

Nov 4-9:17 AM

3. we need more trials to eliminate errors in technique with the instuments.

In conclusion, the value for the density of zinc arrived at by my lab group is:

4.28 g/mL

the accepted value is 7.2 g/mL

With an error of 40%, it is clear we need more practice with the instruments and techniques in the lab.

Nov 4-12:02 PM

When a quantity gets larger or smaller, we say that it changes.

Sometimes a change in one quantity causes a change, or is linked to a change, in another quantity. If these changes are related through equal factors, then the quantities are said to be in direct proportion. Or one might say that the two quantities are directly proportional. As one goes up, the other does as well.

Sep 26-3:00 PM

Two quantities, A and B, are in direct proportion if by whatever factor A changes, B changes by the same factor.

shorthand: α :lower case alpha

– $A \alpha B$

k: constant of proportionality

As an equation:

- $A = kB$

2 quantities are directly proportional if their quotient is a constant (k). $\frac{A}{B} = k$

Sep 26-3:00 PM

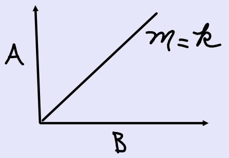
Two quantities are directly proportional if
1. when dividing one by the other gives a constant value
2. When plotted, the graph is a straight line
3. The slope of the line is the constant value.

A	B
1	10
2	20
3	30

$A = kB$

so

$\frac{A}{B} = k$



$m = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{m}{s}$

Sep 28-1:44 PM

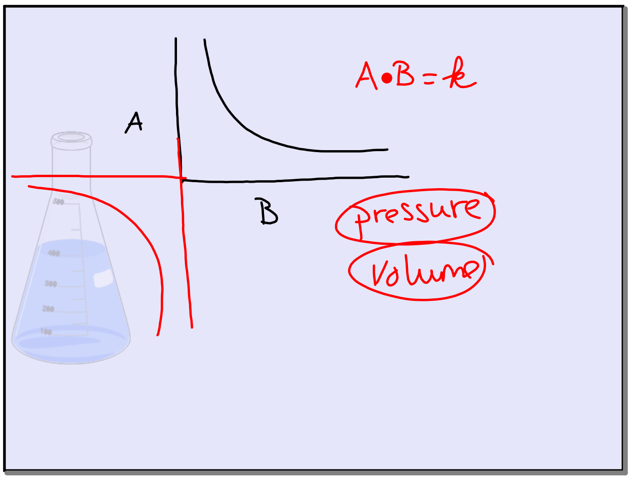
Inverse Proportions

When comparing 2 quantities, A & B, as A increases, B decreases.

If, the product of 2 quantities is a constant, those quantities are inversely proportional.

When graphed, inverse proportions are hyperbolic.

Oct 26-9:36 AM



Sep 29-8:15 AM

What is density? amount of mass in a given volume.

Liter; mL

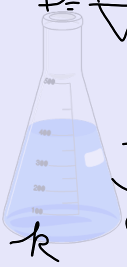
What are the units?

- g/mL
- kg/L
- g/cc
- g/cm^3

$1\,cm^3 = 1\,mL = 1\,cc$

Oct 9-7:43 AM

Density calculations?



$$D = \frac{M}{V} \quad \frac{g}{cm^3}$$

Density is the Mass per unit volume

Intrinsic physical property of matter
doesn't change with amount

V, M Extrinsic physical properties:
change w/ amount of substance.

$\frac{V}{M} = D$

Oct 9-7:49 AM

What do you have to understand to determine density?

Erase to reveal.

Mass

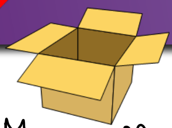
Volume

Formula for Density

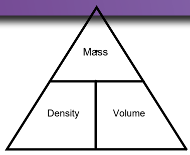
Mar 19-7:45 AM

Mass / Volume

Calculate the density of the box using the formula below.



$D = \frac{M}{V}$; $V = \frac{M}{D}$



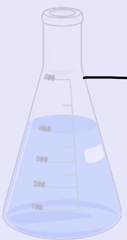
MASS	Volume	Density
26 g	32 cm^3	?

$\frac{26g}{32cm^3} = D$

Click here to go to next page

$0.8125\ g/cm^3 = 0.81\ g/cm^3$

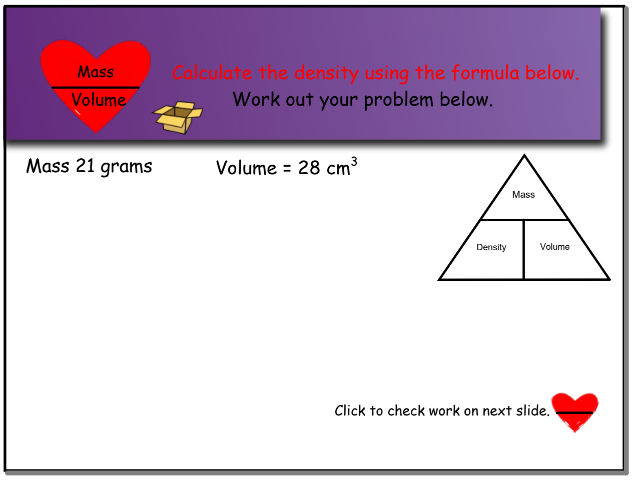
Density problem



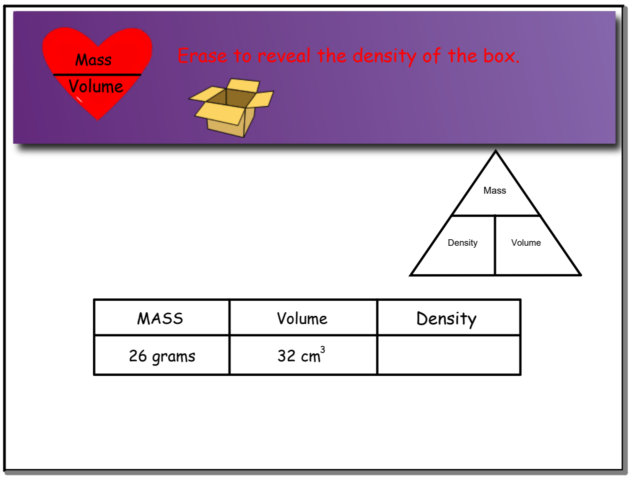
read

80.00

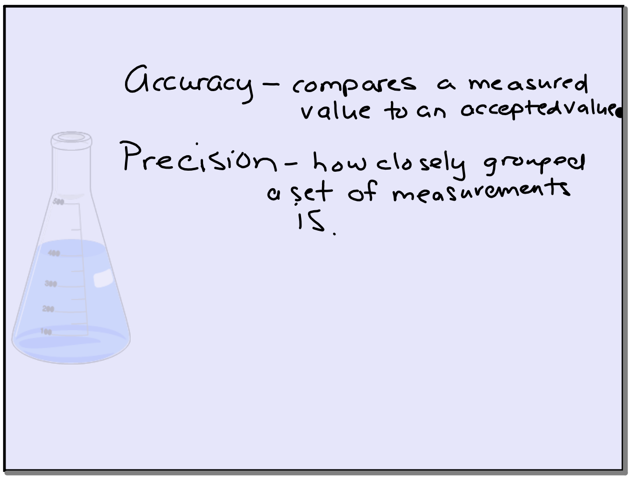
estimated



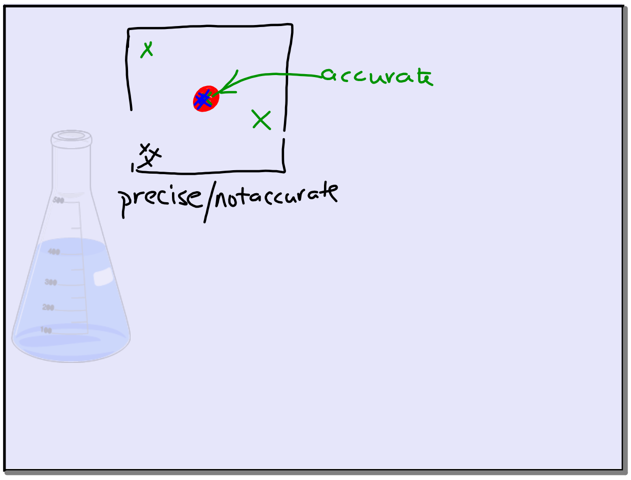
Work problem



Final answer

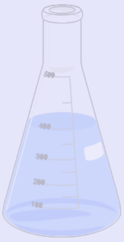


Oct 9-7:51 AM



Oct 9-8:16 AM

$$\%\ error = \frac{|\overset{\text{Given}}{\text{Accepted value}} - \overset{\text{measured}}{\text{exp value}}|}{\text{Accepted value}} \cdot 100\%$$



$$= \frac{|2.35\ g/cm^3 - 2.73\ g/cm^3|}{(2.35\ g/cm^3)} \cdot 100\%$$

$$= 16.2\%$$

Oct 9-8:18 AM

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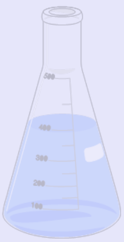

Oct 12-8:09 AM

$(2.46 \cdot 10^{7}) + (34 \cdot 10^{6}) + (2 \cdot 10^{4}) + (1.5 \cdot 10^{5})$

$.015 \cdot 10^{5} = \_ \cdot 10^{7}$

$$
\begin{array}{rl}
2.46 & \cdot 10^{7} \\
.34 & \cdot 10^{7} \\
.002 & \cdot 10^{7} \\
.015 & \cdot 10^{7} \\
\hline
2.817 & \cdot 10^{7}
\end{array}
\Rightarrow \boxed{2.82 \cdot 10^{7}}
$$

Sep 29-12:06 PM

$(4.12 \cdot 10^{-5}) + (3.12 \cdot 10^{-4}) + (1.21 \cdot 10^{-5}) + (5 \cdot 10^{-7})$

$4.12 \cdot 10^{-5} = 0.412 \cdot 10^{-4}$

$1.21 \cdot 10^{-5} = 0.121 \cdot 10^{-4}$

$.005 \cdot 10^{-7} = .005 \cdot 10^{-4}$

$$
\begin{array}{rl}
3.12 & \cdot 10^{-4} \\
.412 & \cdot 10^{-4} \\
.121 & \cdot 10^{-4} \\
.005 & \cdot 10^{-4} \\
\hline
3.658 & \cdot 10^{-4}
\end{array}
$$

$3.66 \cdot 10^{-4}$

Sep 29-12:14 PM