Chemistry 11 - Measurement Notes Key

Unit 2: MEASUREMENT

1. Scientific Notation
2. Metric System
3. Accuracy and Precision
4. Measuring & Counting Significant Figures
5. Calculations with Significant Figures
6. Density

1. Scientific Notation

- A shorthand method of displaying very large (distance to the sun) or very small numbers (lengths of atoms).
- Consists of a coefficient, a base 10, and an exponent
- e.g. 3.95×10^3
- The coefficient must be between 1 and 10 or it is not in scientific notation.
- If the exponent is positive (such as above), the number will be large (greater than 1).
- If the exponent is negative, the number will be small (less than 1).

Express in Scientific Notation

- Ex. $3756 = 3.756 \times 10^3$
- $0.000493 = 4.93 \times 10^{-4}$

Express in Standard Notation

- E.g. $5.21 \times 10^4 =$
  The exponent is positive, so make the coefficient a large number (move the decimal to the right)
  $5.21 \times 10^4 = 52100$
- 2.694×10^{-5}
  The exponent is negative, so make the coefficient a small number (move decimal to the left).
  $2.694 \times 10^{-5} = 0.00002694$

Practice

- Put in scientific notation
- 1. 8720000 =
- 2. 0.0000513 =
- 3. 5302 =
- 4. 0.00117 =
- Put in standard notation
- 5. $7.03 \times 10^{-2} =$
- 6. $1.38 \times 10^4 =$
- 7. $3.99 \times 10^{-5} =$
- 8. $2.781 \times 10^7 =$

Practice - Answers

- 1. $8720000 = 8.72 \times 10^6$
- 2. $0.0000513 = 5.13 \times 10^{-5}$
- 3. $5302 = 5.302 \times 10^3$
- 4. $0.00117 = 1.17 \times 10^{-3}$
- 5. $7.03 \times 10^{-2} = 0.0703$
- 6. $1.38 \times 10^4 = 13800$
- 7. $3.99 \times 10^{-5} = 0.0000399$
- 8. $2.781 \times 10^7 = 27810000$

Write in Scientific Notation:

- 1. 34.79×10^{3} =
- 2. 0.497×10^{6} =
- 3. 19.5×10^{-2} =
- 4. 0.837×10^{-4} =

Write in Scientific Notation - Answers

- 1. $34.79 \times 10^{3} = 3.479 \times 10^{4}$
- 2. $0.497 \times 10^{6} = 4.97 \times 10^{5}$
- 3. $19.5 \times 10^{-2} = 1.95 \times 10^{-1}$
- 4. $0.837 \times 10^{-4} = 8.37 \times 10^{-5}$

To add, subtract, multiply, and divide numbers that are in scientific notation, use your calculator.

1. Type in the coefficient
2. Hit the EXP (or EE or 10^{x} button)
3. Type in the exponent.
If the exponent is negative, use the negative button (-) or +/-. Don't use the subtract button for negatives!

Give the answer in scientific notation
Ex. $(2.56 \times 10^{-4})(3.87 \times 10^{3})$

Answer: 9.91×10^{-1}

Homework:

Scientific Notation Worksheet

2. Metric System

- A measurement must include some form of unit (otherwise it's just a number).
- E.g.
- 10.5 *cm* A length
- 247.93 *g* A mass
- 0.25 *mL* A volume

Base Units

- Common BASIC units of metric

Quantity	Written Unit	Symbol
length	meter	m
mass	gram	g
time	second	s
volume	liter	L
temperature	Degrees Celsius	c
amount	mole	mol

Units Derived from Base Units

Examples of Derived Units

Quantity	Written Unit	Symbol
speed	meter per second	m/s
density	gram per liter	g/L
concentration	moles per liter	M
area	meters squared	m^2
volume	meters cubed	m^3

Common Multiples of Base Units (prefixes)

http://www.youtube.com/watch?v=KfrCaKyhwZk

http://www.media.pearson.com.au/schools/cw/au_sch_derry_ibcsl_1/int/SIPrefix/0106.html

Written Prefix	Prefix Symbol	Equivalent multiplier
mega	M	10^6 = 1 million
kilo	k	10^3 = 1 thousand
hecto	h	10^2 = 1 hundred
deca	da	10^1 = ten
(base)	no prefix	10^0 = one
deci	d	10^{-1} = 1 tenth
centi	c	10^{-2} = 1 hundredth
milli	m	10^{-3} = 1 thousandth
micro	u	10^{-6} = 1 millionth

Move Decimal Right

Move Decimal Left

Chemistry 11 - Measurement Notes Key

Single Unit Conversions

- 27.6 kg = 2760000 cg ?

  We are moving down on our conversion table, therefore we move the decimal to the right. In this case, 5 jumps to the right! The new number is larger because the new unit is smaller.

- 6542mm = 0.06542 hm ?

  We are moving up our conversion table, therefore we move the decimal to the left. In this case, 5 jumps to the left. The new number is smaller because the new unit is larger.

Written Prefix	Prefix Symbol	Equivalent multiplier
mega	M	10^6 = 1 million
kilo	k	10^3 = 1 thousand
hecto	h	10^2 = 1 hundred
deca	da	10^1 = ten
(base)	no prefix	10^0 = one
deci	d	10^{-1} = 1 tenth
centi	c	10^{-2} = 1 hundredth
milli	m	10^{-3} = 1 thousandth
micro	u	10^{-6} = 1 millionth

3 jumps (mega to kilo)

3 jumps (milli to micro)

More Single Unit Conversions

- 0.0723 g = ___________ Mg
- 32.4 daL = ___________ dL
- 2.43×10^{-2} hm = ________ m
- 6.65×10^{3} dg = _________ ug

Answers

- 0.0723 g = 7.23×10^{-8} Mg
- 32.4 daL = 3240 dL
- 2.43×10^{-2} hm = 2.43 m
- 6.65×10^{3} dg = 6.65×10^{8} ug

Double Unit Conversions

- e.g. 2.46 cL/s = __________ mL/ms

- Step 1: To convert the numerator (top) unit, do exactly the same as you would for a single unit conversion.

  e.g. 2.46 cL/s = 24.6 mL/s

- Step 2: To convert the denominator (bottom) unit, do exactly as you would a single conversion, but reverse the direction of your decimal jump.

  e.g. 24.6 mL/s = (three jumps LEFT) 0.0246 mL/ms

Double Unit Con. Examples

- 16.5 cg/hL = ___________ug/L
- 2.34×10^{-1} m/s = __________km/ds

Answers

- 16.5 cg/hL = 1650 ug/L
- 2.34 x 10^{-1} m/s = 2.34 x 10^{-5} km/ds

HOMEWORK:

Metric Worksheet

3. Accuracy & Precision

Accuracy

- Depicts how close a measured value is to the actual value
- EX. If you weigh 150 lbs. But the scale reads 130 lbs., the scale is not accurate.

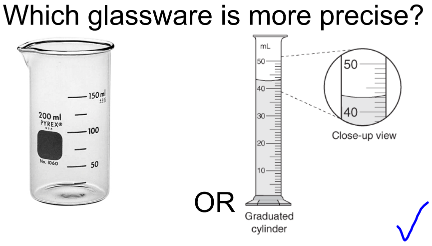
Precision of a single measurement

- A term used to depict how many decimal places (place values) you can acquire from a measuring device
- If scale 1 reads 142.6lbs and scale 2 reads 143lbs, then scale 1 is more precise – it has smaller measuring increments (tenths compared to ones)

Precision of a single measurement

- 1) Which measurement is more precise?
  a. 2.3 cm (b.) 2.32 cm

2) Which glassware is more precise?



PRECISION OF MULTIPLE MEASUREMENTS

- Precision can be used to describe reproducible measurements as well
- Ex. You weigh the same piece of zinc on a scale 3 times, and you get 7.60, 7.61, and 7.59 grams. the scale is precise (it gives reproducible results).

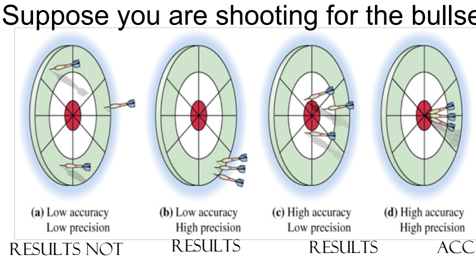
THE TWO MEANINGS OF PRECISION

1. To how many decimal places a measuring device can measure to (the more decimal places, the more precise)
2. The reproducibility of a measurement. If you measure something three times, will the measuring device give the same result every time.

A scale that is giving incorrect masses (is not accurate), but does give reproducible results (is precise) needs to be CALIBRATED (kind of like setting your watch to the correct time).

A scale that is not precise could mean two things:
-either it doesn't measure to many decimal places OR
-it doesn't give reproducible results
-OR both

Suppose you are shooting for the bullseye!



RESULTS NOT ACCURATE OR REPRODUCIBLE | RESULTS INACCURATE BUT REPRODUCIBLE | RESULTS ACCURATE BUT NOT REPRODUCIBLE | ACCURATE AND REPRODUCIBLE

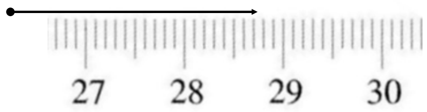
http://www.youtube.com/watch?v=_LL0uiOgh1E

4. Measuring & Counting Significant Figures

Significant Figures

- When counting objects we can find an exactnumber that's undisputable (100% accurate)
  - eg numbers of students in class,number of books on a shelf
- When measuring quantities you are alwayslimited by the precision of the measuring device(what place value it can measure to). The precision can always be better (to infinity), thus you can never get a completely accurate, undisputable measurement
  - eg length of classroom, mass of person
- When making a measurement, there is a limit to the amount of meaningful digits

For example, measure the length of the arrow using the ruler:



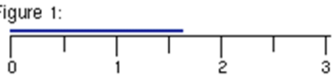
You couldn't say the measurement was 28.7392743. There's a limit to the amount of digits in your measurement that are <u>meaningful</u>.

Significant Figures

- A significant figure (or significant digit) is a measured or meaningful digit.
- Significant figures (or "Sig figs") are the digits <u>known to be exact plus one more that may have some uncertainty but is an educated guess</u>
- The following examples show how many digits can be determined in different cases.

How long is each line?

Figure 1:



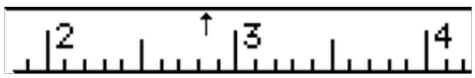
In Figure 1: 1.6cm, 2 sig figs

Figure 2:

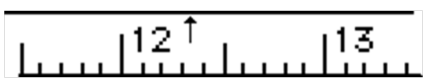
In Figure 2:1.63cm (or 1.62 or 1.64), so 3 s.f.

The number of sig figs consists of certain digits + one uncertain (educated guess) digit.

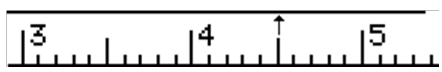
The precision of the measuring device determines the number of sig figs. Fig. 2 has a higher precision



- We state the measurement as 2.82 cm.
- We are certain about the first 2 digits and have some certainty about the third
- eg - we know the third digit is not 0 or 9, (but it might be 1 or 3)
- This measurement has 3 sig figs
- We cannot give the measurement of 2.8275 because we cannot be that precise with this ruler



- Estimated length = 12.33 cm
- 4 significant figures



Scale?

tenths

Which digits of this measurement are certain? 4.5

What is the guess digit, then? A zero

So the measurement has __3__ sig figs and is _4.50__ cm

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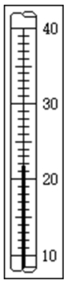


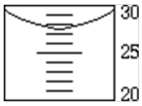
How many degrees Celsius?

Scale?

ones

Measurement: 21.8°C

# of sig figs: 3



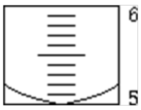
Graduated Cylinder

Measurement: 27.5 mL

Scale?

ones

# of sig figs: 3



Graduated Cylinder

Measurement: 5.00 mL

Scale?

tenths

# of sig figs: 3

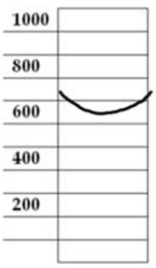
If the increments on a measuring device don't change by 1 (or 0.1 or 0.01 etc), but change by 2 or 5, use educated guessing when making a measurement. If the last guess digit random, it should not be a sig fig.

Measure:

332mL

Measure:

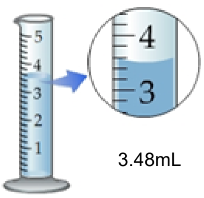
a)



640mL

mL

b)



3.48mL

mL

What if the measurement has been made by someone else, and then you are to work with it? This occurs all the time in Science. How do you count the number of sig figs in the measurement?

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Rules for Counting Significant Figures

- A) all <u>non-zero</u> digits are significant
- B) zeros are significant if:
- They are at at the end of a number to the right of the decimal point. ex. 2.50 (3 sig figs as the 0 counts)
- They are sandwiched by non-zero numbers. ex. 2002 (4 sig figs) or 10.003 (5 sf)
- C) zeros that help define the number are not significant (zeros at the end of a number to the left of the decimal). ex. 100 has only 1 sig fig but 100.0 has 4 sig figs
- OR zeros leading off a number ex. 0.00034 has 2sf

Examples

- 34.500
- 5 significant figures
- 0.0087
- 2 significant figures
- 350.007
- 6 significant figures
- 1500
- 2 significant figures
- 120.0
- 4 significant figures

Scientific Notation & Sig Figs

- What if you measure 100 to three sig figs? How would you show this?
- Use scientific notation: 1.00×10^2 is 100 expressed with three sig figs
- Sig figs for scientific notation:
- The number of digits in the coefficient IS the number of sig figs!
- Express 100 with two sig figs: 1.0×10^2
- Express 100 with 1 sig fig 2 ways: 100
- 1×10^2

Same number with different amounts of Sig. Figs. How many sig figs for each?

- 1200 2
- 1200.0 5
- 1.2×10^3 2
- 1.20×10^3 3
- 1.200×10^3 4

Perfect Numbers

- REMEMBER: Counting numbers or defined values are considered to be exact or perfect numbers and are exempt from rules of sig. figs.
- 7 cheers for chemistry! (counting #)
- 100cm = 1m (conversions: defined values)

Practice - How many Sig Figs

- 13.0 mm
- 48.07 g
- 0.050 cm
- 1001 L
- 5 students
- 15000 g
- 1 L = 1000 mL
- 3.00×10^{-3} kg

Practice - How many Sig Figs

- 13.0 mm 3 sig figs
- 48.07 g 4 sig figs
- 0.050cm 2 sig figs
- 1001 L 4 sig figs
- 5 students perfect number
- 15000 g 2 sig figs
- 1 L = 1000 mL perfect number
- 3.00×10^{-3} 3 sig figs

Homework:
Counting Sig Figs Worksheet AND Measuring with Sig Figs Worksheet

http://www.youtube.com/watch?v=ZuVPkBb-z2I

5. Calculations with Significant Figures

Significant Figures and Mult/Division

- The answer can have no more *SIG FIGS* than the *LEAST* significant of all terms
- E.g. 10.4 x 4.1 x 0.03963
- (3 sig figs) (2 sig figs) (4 sig figs)
- Answer can only be given to 2 sig figs
- Calculator gives = 1.6898232
- Answer = 1.7 (2 sig figs)

- E.g. $\frac{(3.428 \times 10^{5}) \times (5.98 \times 10^{-2})}{8.7615 \times 10^{4}}$
- Least number of sig figs is 3 so answer must be rounded to 3 sig figs
- Calculator gives 0.233971808483
- Answer is 0.234 or, in sci. notation, the answer is 2.34×10^{-1}

Sig Figs and Addition/Subtraction

- The answer goes to the same PLACE VALUE of the term that is least precise

- E.g. 3.4893
- + 0.35
- + 0.17938

4.01868 = 4.02

0.35 is least precise of the three measurements (only to hundredths)

- Answer can only have 2 decimal places

- E.g. 583.4 - 1.256 =

- 583.4
- 1.256

582.144

Line up decimal places

= 582.1 (One decimal place)

- When adding or subtracting in scientific notation, change the number to standard form first, and then calculate answer using sig figs.
- $5.43 \times 10^{-4} + 6.235 \times 10^{-1}$
- 0.000543
- + 0.6235
- 0.624043

Answer: 6.240×10^{-1}

Calculating Tips

- Always carry a couple extra unsignificant digits when doing calculations, so you don`t have rounding errors
- Round off only the ***FINAL ANSWER*** to the correct number of significant digits.

ex. find 34.3 x 0.3455 Then, square the answer and divide by 3.00	answer when rounding after each step:	answer when carrying extra digits:
	47.3	46.8

Mixed Calculations

- Evaluate to the correct amount of sigfigs:
- 50.35 x 0.106 – 25.37 x 0.18 =
- Order of operations → BEDMAS
- Multiply 1st…but show sigfigs in bold:
- 50.35 x 0.106 = **5.33**71
- 25.37 x 0.18 = **4.5**666

- Now…perform the subtraction operation.
- Since both of the multiplications are ‘legal’ to the 2nd decimal place, the result of the subtraction operation must be rounded to the 2nd decimal place as follows:
- **5.33**71 – **4.5**666 = **0.7**705
- The answer is then rounded to **0.8**
- Again, always carry more digits through to the end, and round to the proper number of sigfigs at the end only.

HOMEWORK:

Sig Fig Calculation Worksheet

http://www.wwnorton.com/college/chemistry/gilbert2/chemtours.asp

6. Density

What's more dense?

A big box of wooden chairs OR A little piece of iron ✓

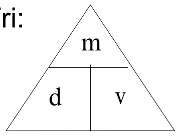
http://www.youtube.com/watch?v=H2RIt3YM1To

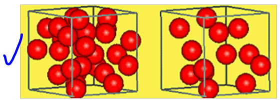
Density

- Definition: The mass contained in a given volume of space

Formula: d = m / v

Eqn Tri:



✓ 

Which is more dense??

Units

- Mass: mg, g, kg
- Volume: m^3 , cm^3, L, mL (1cm^3 = 1mL)
- Density: g/cm^3, g/mL, kg/L etc.

Example

1.0mL of water at 4°C has a mass of 1.0g.

- Therefore, the density of water is...

- 1.0 g/mL

Density determines whether an object sinks or floats!

- Is the density of ice greater than or less than water?
- LESS THAN (it floats!)
- Is the density of ice greater than or less than isobutanol?
- GREATER THAN (it sinks!)

- Will the following sink or float in water?
- Aluminum 2.70 g/cm^3 SINK
- Cork 0.72 g/cm^3 FLOAT
- Cooking Oil 0.920 g/mL FLOAT

- How do you know?
- Compare with the density of water.

http://www.kentchemistry.com/links/Measurements/Density.htm

both videos

- Density of Some Common Substances

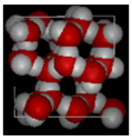
	Density (g/cm^3) or (g/mL)	
Air	0.0012	
Feathers	0.0025	
Wood(Oak)	0.6 - 0.9	
Ice	0.92	
Water	1.00	
Bricks	1.84	
Aluminum	2.70	
Steel	7.80	
Silver	10.50	
Gold	19.30	

Density is an <u>intensive</u> property of a substance, meaning it's the same for a substance no matter the size or mass of the substance (at a specific temperature).

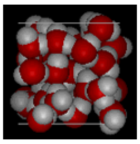
- Is density temperature dependent? Yes!
  - As a substance's temperature increases, the molecules move faster and space out, therefore density decreases (less mass in a given volume).
  - As a substance's temperature decreases, the molecules move slower and pack in, therefore density increases (more mass in a given volume).
  - For most substances, density is ranked as follows

    solid phase > liquid phase > gas phase

So why does ice float?



- When water solidifies to make ice, H_2O molecules are kept a certain distance from one another due to hydrogen bonds between molecules. These H-bonds hold the molecules further apart compared to liquid phase



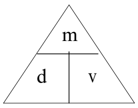
- Liquid H_2O molecules still have hydrogen bonding, but the increased kinetic energy of the molecules allows for more movement and thus molecules are able to be closer together (H-bonds form and re-form with great frequency due to the high KE).

http://preparatorychemistry.com/water_flash.htm

*very end of animation

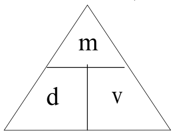
Examples of Density Problems

- An iron bar has a mass of 19600g and a volume of 2.50L. Find the density of the bar in g/L.



$$\text{density} = \frac{19\,600\text{g}}{2.50\text{L}} = 7840 \text{ g/L}$$

- Mercury has a density of 13600g/L. What volume (in mL) is occupied by 425g of Mercury?



$$v = \frac{m}{d} = \frac{425\text{g}}{13\,600\text{L}} = 0.0313\text{L} = 31.3\text{mL}$$

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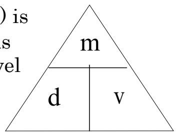
- A 25.0g piece of steel (denisty 7.80g/cm^3) is dropped into a graduated cylinder that has 16.00mL of water. What will the water level be after the steel has been added? REMEMBER: 1cm^3 = 1mL



$$v = \frac{m}{d} = \frac{25.0\text{g}}{7.80\text{g/mL}} = 3.21\text{mL}$$

16.00 + 3.21mL = 19.21mL

<u>Homework:</u>

Density Worksheet

http://www.youtube.com/watch?v=fE2KQzLUVA4&feature=results_main&playnext=1&list=PLD2AE3B1A10707D42

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