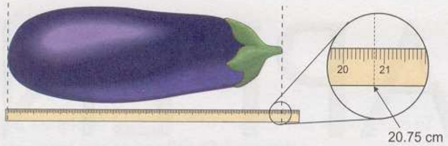
Counting Significant Figures

It's no good learning how to do chemistry calculations really well if you then go and lose points because you don't know the rules about significant figures.

Measurements are often not exact

When you measure something using a measuring device such as a balance or a ruler, you can never get a completely exact measurement.

For example, if you measure the length of this eggplant using the ruler shown, you can see that its length falls between the marks for 20.7 cm and 20.8 cm.



To get the second decimal place of the measurement, you need to estimate — you might estimate the eggplant's length to be 20.75 cm, but other people might estimate the length to be 20.74 cm or 20.76 cm.

The first three digits (20.7) will always be the same, no matter what the fourth digit is estimated to be — these are called the certain numbers of the measurement. The fourth digit is only estimated and is known as an uncertain number.

When you measure something, whether it's a length, a mass, or a volume, you should write down all the certain numbers and the first uncertain number. These are called the significant figures.

There are three important rules for counting significant figures in a number

These are fairly straightforward — apart from the zeros, which complicate things no end:

1. **NONZERO DIGITS** — These always count as significant figures.
   So 56,823 has five significant figures, and 2.67 has three.
2. **ZEROS** (eeek) — There are three types of zeros, depending on where they are in the number:
   - Zeros at the beginning — These never count as significant figures.
     For example, the number 0.045 has only two significant figures (4 and 5), and 0.0003 has only 1 significant figure (3).
   - Zeros between other digits — These always count as significant figures.
     For example, the number 405 has three significant figures, and 6022 has four.
   - Zeros at the end of a number — These only count as significant figures if the number is written with a decimal point.
     So the number 8690 has three significant figures, but if you write it as 8690. then it has four. The decimal point can be anywhere in the number — 0.00490 has three significant figures.
3. **EXACT NUMBERS** — These have unlimited numbers of significant figures.
   Exact numbers are things you count rather than measure, like 7 rabbits or 123 atoms. You know that these numbers are absolutely certain and there aren't actually 6.95 rabbits or 123.47 atoms.

Example:

The zeros at the start are not significant.

4 and 6 and the zeros between them are all significant.

The zeros at the end are significant because the number contains a decimal point.

0.00400600

So this number has **six significant figures**: 1st 2nd 3rd 4th 5th 6th

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Rounding Off

Rounding off to the correct number of significant figures

You'll often end up with an answer with more significant figures than you need. In such cases, you'll need to round off.

The basic method for rounding off has three steps:

1. Identify the **position of the last significant digit** you want to keep.
2. Look at the **next digit to the right** — called the **decider**.
3. If the decider is **5 or more**, then **add 1 to** the last significant digit you want to keep.
   If the decider is **less than 5**, then **don't change** the last significant digit you want to keep.

Example: Round 7.45839 to 3 significant figures.

7.45839 = **7.46** (3 significant figures)

Position of last significant digit to keep.

Decider

DON'T ROUND TOO EARLY — If you need to use your result for another step in the calculation, use the unrounded number in your calculator — only round your **final answer**.

Make sure your answers have the correct number of significant figures

Before you can round off your answer, you need to know how many significant figures you're aiming for. There are a few rules for this too...

When multiplying or dividing:

The number of **significant figures** in the result should be the same as in the measurement with the **smallest** number of **significant figures**.

Examples:

5.67 × 4.9 = 27.783 ⇒ **28**
(3 s.f.) (2 s.f.) (2 s.f.)

The smallest number of significant figures in the measurements is 2, so the result must have 2 significant figures also.

0.0573 ÷ 1.824 = 0.031414473... ⇒ **0.0314**
(3 s.f.) (4 s.f.) (3 s.f.)

The smallest number of significant figures in the measurements is 3, so the result must have 3 significant figures also.

For addition or subtraction, it's the number of decimal places in the measurements that's important.

When adding or subtracting:

The number of **decimal places** in the result should be the same as in the measurement with the **smallest** number of **decimal places**.

Examples:

14.73 + 8.8 + 0.739 = 24.269 ⇒ **24.3**
(2 d.p.) (1 d.p.) (3 d.p.) (1 d.p.)

The smallest number of decimal places in the measurements is 1, so the result must have 1 decimal place too.

18.924 − 8.92 = 10.004 ⇒ **10.00**
(3 d.p.) (2 d.p.) (2 d.p.)

The smallest number of decimal places in the measurements is 2, so the result must have 2 decimal places too.

Name:_______________________________________ **Significant Figures Worksheet #1**

Part A: Number of Signifigcant Figures

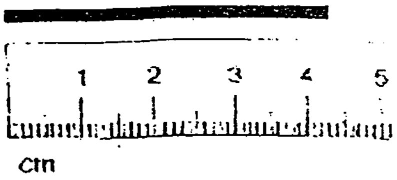
1) Determine which rule you need to use: Atlantic Rule (A) or Pacific Rule (P)

Determine the number of significant figures in the measurement

Number	Atlantic Rule (A) or Pacific Rule (P)	# or sig figs	Number	Atlantic Rule (A) or Pacific Rule (P)	# of sig figs
1) 650 g			6) 10.50 j		
2) 54.0 s			7) 302 mL		
3) 1500. m			8) 5.200 L		
4) 0.420 g			9) 0.78 m		
5) 5000 mg			10) 0.07Km		

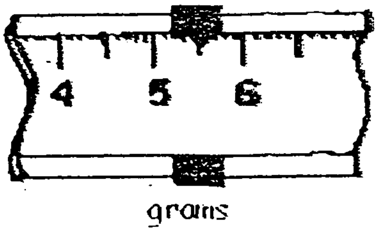
Part 2: Reading to the Correct Precision Read the following tool to the correct precision. Remember to go one more place than the smallest marking on the tool and include the unit with your answer.

RULER



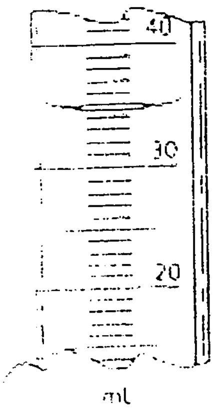
11. ________________

BALANCE



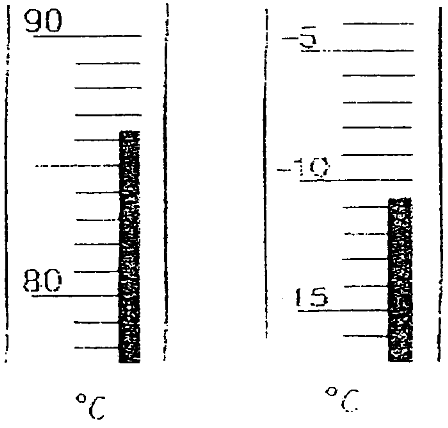
12. ________________

GRADUATED CYLINDER



13. ________________

THERMOMETERS



14. __________ 15. __________

Name ________________________________

Atlantic/Pacific Rule:

If there is a decimal point in a measurement, count significant digits from the Pacific Side (left side) at the first non-zero. If there is no decimal point, count significant digits from the Atlantic Side (right side) at the first non-zero.

Complete the following math problems. Record your answer to the correct number of significant figures. (Remember the rules depend if you are doing addition/subtraction or multiplication/division.)

1) 951.0L
1407 L
23.911 L
\+ 158.18 L

2) 53.316 m
2.01 m
\- 13.0 m

3) 102.536 g
11.8 cm^3

4) 3.05 m
x 2.10 m

5) 749.4 mi
x 0.002 mi

6) 13.4 mm
2.1 mm

7) 0.045 sec
-0.03 sec

8) 1 mL
\+ 3.245 mL

9) 524.01g + 1.0g =

10) 235.046 m + 24.81 m =

11) 5.0 s x 8.50 s =

12) 3400L – 235 L =

13) 999.48 cm – 89.0 cm =

14) 0.3287 g x 45.2 g =

15) 0.258 mL + 0.36105 mL =

16) 125.5 kg + 52.68 kg + 2.1 kg =

17) 5.0 s x 8.50 s =

18) 9.150 mm x 1. 1mm =

19) 175.0 g/ 25 mole =

20) 350. g / 100 mL =

21) (0.12 g + 5.16 g) x (45.56 g – 93.0 g) =

Measurement and Significant Figures

1) Balance Station # ______ Precision & Unit 0.01g

Object	Mass	# of Sig Figs
Rubber Stopper		
Sea Shell		
Rock		

2) Thermometer Station # ______ Precision & Unit 0.1°C

Beaker #	Temperature	# of Sig Figs
1		
2		
3		

3) Centimeter Ruler Station #______ Precision & Unit 0.01cm

Line #	Length	# of Sig Figs
1		
2		
3		

4) Volume Station # ______ Precision & Unit 0.1ml

Graduated Cylinder #	Volume	# of Sig Figs
1		
2		
3		

5) *Identify the number of significant figures each measurement contains:*

Measurement	# of Sig Figs
2.304 g	
10.01 cm	
12.0°C	
0.095 g	
75.2 mL	

	Calculated Value	Rounded-Off	#s.d.
6.	6.249 mm		2
7.	10.98 g		3
8.	0.0573 mol		2
9.	69.95 km/h		3
10.	296.038 cm^3		4

	Value	# s.d.	Scientific Notation
1.	0.007 06 g	2	
2.	4 000 000 m	3	
3.	43 059 mL	3	
4.	0.003 49 L	1	
5.	38 100 mm	4	
6.	0.004 45 s	2	

measurement

PRACTICE PROBLEMS

Use Reference Table T

1.
The mass of a solid is 3.60 grams and its volume is 1.8 cubic centimeters. What is the density of the solid, expressed to the correct number of significant figures?

A. 2 g/cm^3

B. 2.0 g/cm^3

C. 0.5 g/cm^3

D. 0.50 g/cm^3

2.
What is the sum of 0.04321 g + 5.263 g + 2.13 g to the correct number of significant digits?

A. 7 g C. 7.44 g

B. 7.4 g D. 7.435 g

3.
Which measurement contains three significant figures?

A. 0.08 cm C. 800 cm

B. 0.080 cm D. 8.08 cm

4.
A student determined the heat of fusion of water to be 88 calories per gram. If the accepted value is 80. calories per gram, what is the student's percent error?

A. 5.0% C. 11%

B. 10.% D. 90.%

5.
Given: (52.6 cm)(1.214 cm)
What is the product expressed to the correct number of significant figures?

A. 64 cm^2

B. 63.9 cm^2

C. 63.86 cm^2

D. 63.8564 cm^2

6.
A student calculated the percent by mass of water in a hydrate as 14.2%. A hydrate is a compound that contains water as part of its crystal structure. If the accepted value is 14.7%, the student's percent error was

A. $\frac{0.5}{14.2} \times 100$

B. $\frac{14.7}{14.2} \times 100$

C. $\frac{0.5}{14.7} \times 100$

D. $\frac{14.2}{14.7} \times 100$

7.
Which mass measurement contains four significant figures?

A. 0.086 g C. 1003 g

B. 0.431 g D. 3870 g

8.
Expressed to the correct number of significant figures, the sum of two masses is 445.2 grams. Which two masses produce this answer?

A. 210.10 g + 235.100 g C. 210.1 g + 235.1 g

B. 210.100 g + 235.10 g D. 210.10 g + 235.10 g

9.
A student intended to make a salt solution with a concentration of 10.0 grams of solute per liter of solution. When the student's solution was analyzed, it was found to contain 8.90 grams of solute per liter of solution. What was the percent error in the concentration of the solution?

A. 1.10% C. 11.0%

B. 8.90% D. 18.9%

10.
A student calculates the density of an unknown solid. The mass is 10.04 grams, and the volume is 8.21 cubic centimeters. How many significant figures should appear in the final answer?

A. 1 C. 3

B. 2 D. 4

11. put in box
A hydrated compound contains water molecules within its crystal structure. The percent composition by mass of water in the hydrated compound $CaSO_4 \cdot 2H_2O$ has an accepted value of 20.9%. A student did an experiment and determined that the percent composition by mass of water in $CaSO_4 \cdot 2H_2O$ was 21.4%.
Calculate the percent error of the student's experimental result.

Answer: ☐%

1) What is the number 215.0 expressed in proper scientific notation with the correct number of significant digits?

A) 2.150×10^2 C) 2.15×10^2

B) 2.150×10^{-2} D) 2.15×10^{-2}

2) What is the number 2.1×10^3 expressed in conventional form with the proper number of significant digits?

A) 0.0021 C) 2,100.

B) 21,000. D) 2,100

3) What is the number 8.90×10^{-4} expressed in conventional form with the correct number of significant digits?

A) 0.000890 C) 0.00089

B) 89,000. D) 89,000

4) What is the number 0.00034 expressed in proper scientific notation with the correct number of significant digits?

A) 3.40×10^{-4} C) 3.4×10^4

B) 3.40×10^4 D) 3.4×10^{-4}

The World of Chemistry **Name:** ______________ **Class period:** _____

Measurement: The Foundation of Chemistry

1. Measurements can tell us what is in a substance and how much is there. What else must be true about these measurements?

2. Several examples were given of measurements that are made on an everyday basis. In what areas were these measurements made? List two.

3. What is meant when we say one balance is more "sensitive" than another? It can measure to
   a) more decimal places b) fewer decimal places

4. How do we know if an instrument such as a balance is displaying the proper value for the mass of an object?

5. The role of the Bureau of Standards is to design ways to measure and provide standards. True or False

6. Why are human standards (like a former King of England) not desirable?

7. Match the terms (titration and standard solution) with their proper explanation:
   a. A solution of known chemical concentration __________________
   b. A method for finding the concentration of a solution __________________
8. When the bay water was tested for salinity, what evidence of chemical change took place?

9. Why is it important to know the amount of pollutants, such as mercury, present in water?

10. What is spectroscopy? It determines the concentration of a solution from the intensity of it's
    a) color b) phase c) composition

11. What is meant by precision? Is it possible for measurements to be precise but inaccurate?

12. Why are repeated trials of the same measurement desirable?

13. Pollutants and trace minerals are often reported in units called ppm. What is a ppm?

14. Measurements may be made directly and indirectly. Give an example of each that you saw in the video.
    Direct:

    Indirect: