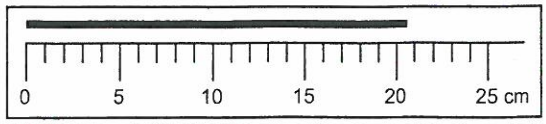
Name:____________________
Blk:______Date:______________

SIGNIFICANT DIGITS



The length of the line is approx. 20.7 cm. The 2 and 0 are certain, the 7 is uncertain. All three digits are significant.

Summary: associated with every measurement made is some degree of uncertainty. For instance, you might measure the length of the dark line shown in the diagram as 20.7 cm. The digits 2 and 0 are certain - there is no doubt that the length is "20 point something" cm. The 7 is uncertain - it might be a little less or a little more. The number of 'significant digits' indicates the certainty of our measurement. There are three significant digits in this case (20.7). Thus, significant digits in a measurement or calculation consist of all those digits that are certain, plus one uncertain digit. Although your calculator may give you an answer to eight decimal places or more, you should not include all of these digits in your answer.

Rules For Determining The Number Of Significant Digits

If you have trouble determining the number of significant digits, follow these steps.

1. All digits from 1 to 9 (non-zero digits) are considered to be significant.

Example	Number of significant digits
1.23 g	3

2. Zeros between non-zero digits are always significant

1.03 g	3

3. Zeros to the left of non zero digits, serve only to locate the decimal point; they are not significant.

0.00123 g	3; zeros to the left of the 1 simply locate the decimal point. To avoid confusion you can write numbers in scientific notation. I.e. $0.00123 = 1.23 \times 10^{-3}$

4. Any zero printed to the right of a non-zero digit is significant if it is also to the right of the decimal point.

2.0 g and 0.020 g	2 for both; all zeros that are right of both a non-zero digit and the decimal point are significant.

5. Any zero printed to the right of a non-zero digit may or may not be significant if there is no decimal point indicated. For example, if someone tells you that a mountain is 3600 m high they are probably certain of the 3, and uncertain of the 6. In other words, there are likely 2 significant digits. However 3600 m may also have 3 significant digits (if the measurement was taken to the nearest 10 m) or 4 significant digits if the measurement was taken to the nearest 1 m).

100 g	1, 2, or 3; in numbers that do not contain a decimal point, "trailing" zeros may or may not be significant. To eliminate possible confusion, one practice is to underline the last significant digit. Thus, $1\underline{0}0$ has two significant digits, whereas $10\underline{0}$ has three. Ideally, we write the number in scientific notation: for example 1.0×10^{-2} has two significant digits and 1.00×10^{-2} has three significant digits. Notice that for numbers written in scientific notation, all digits are significant.

6. Any number that is counted instead of measured has an infinite number of significant digits.

3 test tubes	Infinite; exact numbers, for example, the number of meters in a kilometer or numbers obtained by counting (4 people, 5 beakers), are said to have an infinite number of significant digits.

A) How many significant digits do the following measured quantities have?

i) 2.83 cm	iii) 14.0 g	v) 0.02 mL	vii) 2.350×10^{-2} L	ix) 3 fingers
ii) 36.77 mm	iv) 0.0033 kg	vi) 0.2410 km	viii) 1.00009 L	x) 0.0056040 g

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B) i) 83.25 – 0.1075 ii) 4.02 + 0.001 iii) 0.2983 + 1.52

C) i) 7.255 ÷ 81.334 ii) 1.142 x 0.002 iii) 31.22 x 9.8

D) Solve the following (do one step at a time, according to BEDMAS): i) 6.12 x 3.734 + 16.1 ÷ 2.3
ii) 0.0030 + 0.02 iii) $1.70 \times 10^3 + 1.34 \times 10^5$ iv) (33.4 + 112.7 + 0.032)/(6.487)

E) Convert these measurements: i) 1.0 cm = ______ m, ii) 0.0390 kg = ______ g, iii) 1.7 m = _____ mm

SIGNIFICANT FIGURES

Name Key

measurement can only be as accurate and precise as the instrument that produced it. scientist must be able to express the accuracy of a number, not just its numerical value. We can determine the accuracy of a number by the number of significant figures it contains.

1) All digits 1-9 inclusive are significant.
   Example: 129 has 3 significant figures.
2) Zeros between significant digits are always significant.
   Example: 5,007 has 4 significant figures.
3) Trailing zeros in a number are significant <u>only</u> if the number contains a decimal point.
   Example: 100.0 has 4 significant figures.
   100 has 1 significant figure.
4) Zeros in the beginning of a number whose only function is to place the decimal point are not significant.
   Example: 0.0025 has 2 significant figures.
5) Zeros following a decimal significant figure are significant.
   Example: 0.000<u>470</u> has 3 significant figures.
   0.<u>47000</u> has 5 significant figures.

Determine the number of significant figures in the following numbers.

1. 0.02 1
2. 0.020 2
3. 501 3
4. 501.0 4
5. 5,000 1
6. 5,000. 4
7. 6,051.00 6
8. 0.0005 1
9. 0.1020 4
10. 10,001 5

Determine the location of the last significant place value by placing a bar over the digit. (Example: $1.70\bar{0}$)

1. 8040 $80\bar{4}0$
2. 0.0300 $0.030\bar{0}$
3. 699.5 $699.\bar{5}$
4. 2.000×10^2 $2.00\bar{0} \times 10^2$
5. 0.90100 $0.9010\bar{0}$
6. 90,100 $90,\bar{1}00$
7. 4.7×10^{-8} $4.\bar{7} \times 10^{-8}$
8. 10,800,000. $10,800,00\bar{0}.$
9. 3.01×10^{21} $3.0\bar{1} \times 10^{21}$
10. 0.000410 $0.00041\bar{0}$

CALCULATIONS USING SIGNIFICANT FIGURES

Name Key

When multiplying and dividing, limit and round to the least number of significant figures in any of the factors.

> **Example 1:** 23.0 cm x 432 cm x 19 cm = 188,784 cm^3
> The answer is expressed as 190,000 cm^3 since 19 cm has only two significant figures.

When adding and subtracting, limit and round your answer to the least number of decimal places in any of the numbers that make up your answer.

> **Example 2:** 123.25 mL + 46.0 mL + 86.257 mL = 255.507 mL
> The answer is expressed as 255.5 mL since 46.0 mL has only one decimal place.

Perform the following operations expressing the answer in the correct number of significant figures.

1. 1.35 m x 2.467 m = 3.33 m^2
   (3) (4)
2. 1,035 m^2 ÷ 42 m = 25 m
   (4) (2)
3. 12.01 mL + 35.2 mL + 6 mL = 53 mL
4. 55.46 g − 28.9 g = 26.6 g
5. .021 cm x 3.2 cm x 100.1 cm = 6.7 cm^3
   (2) (2) (4)
6. 0.15 cm + 1.15 cm + 2.051 cm = 3.35 cm
7. 150 L^3 ÷ 4 L = 40 L^2
   (2) (1)
8. 505 kg − 450.25 kg = 55 kg
9. 1.252 mm x 0.115 mm x 0.012 mm = 0.0017 mm^3
   (4) (3) (2)
10. 1.278 x 10^3 m^2 ÷ 1.4267 x 10^2 m = 8.958 m
    (4) (5)

Name: Key
Blk:_____ Date:_____

Chemistry 11
SCIENTIFIC NOTATION + SIGNIFICANT FIGURES

Why use Scientific Notation?

→ Sometimes it is useful to be able to express either LARGE or SMALL numbers in a simplified manner.

→ Expressing #'s to the base of 10 allows for more efficient + simplified calculations.

1. Converting Ordinary Notation into Scientific Notation:

a. 299 793 000 → 2.99793×10^{8}

b. 0.000 000 589 3 → 5.893×10^{-7}

2. Converting Scientific Notation into Ordinary Notation:

a. 1.8×10^{6} → 1800000

b. 5.39621×10^{-9} → 0.00000000539621

3. Mathematics of EXPONENTS

When multiplying you ADD exponents

Ex. $10^{6} \times 10^{4} = 10^{10}$

When dividing you SUBTRACT exponents

Ex.

$$\frac{10^{8}}{10^{4}} = 10^{4}$$

4. Using your SCIENTIFIC CALCULATORS to perform mathematical calculations involving Scientific Notation.

A. $(5.8 \times 10^{3})(6.7 \times 10^{-5})$

i. Enter (5.8 EXP 3)

ii. Enter (x)

iii. Enter (6.7 EXP (−) 5)

iv. Convert answer into correct number of sig figs

$\therefore (5.8 \times 10^{3})(6.7 \times 10^{-5}) = 0.3886 \rightarrow \boxed{3.9 \times 10^{-1}}$

(2) (2)

B. $(2.7 \times 10^{-5}) \div (3.9 \times 10^{-3})$

v. Enter (2.7 EXP −5)

vi. Enter (÷)

vii. Enter (3.9 EXP − 3)

viii. Convert answer into correct number of sig figs

$\therefore (2.7 \times 10^{-5}) \div (3.9 \times 10^{-3}) = 0.006923 \longrightarrow \boxed{6.9 \times 10^{-3}}$

(2) (2)

C. $(3.5 \times 10^{3}) + (5.4 \times 10^{5})$

ix. Enter (3.5 EXP 3)

x. Enter (+)

xi. Enter (5.4 EXP 5)

Convert answer into correct number of sig figs

$\therefore (3.\underline{5} \times 10^{3}) + (5.\underline{4} \times 10^{5}) = 543500 \longrightarrow \boxed{5.4 \times 10^{5}}$

(1 dec) (1 dec)

D. $(6.25 \times 10^{4}) - (3.52 \times 10^{5})$

xii. Enter (6.25 EXP 4)

xiii. Enter (−)

xiv. Enter (3.52 x 10^{5})

Convert answer into correct number of sig figs

$\therefore (6.\underline{25} \times 10^{4}) - (3.\underline{52} \times 10^{5}) = -289500 \longrightarrow \boxed{2.90 \times 10^{5}}$

(2 dec) (2 dec)

55. (a) 3 (b) 5 (c) 5 (d) 2 (e) 3 (f) 3 (g) 4 (h) 4 (i) 6 (j) 4

56. (a) 6.3 (b) 0.000 24 (c) 1.33 (d) 1.3×10^2 (e) 3×10^{14} (f) 5.11×10^5 (g) 202 (h) 90 (i) 20 (j) 1×10^{-4} (k) 2 (l) 2.2 x 1(

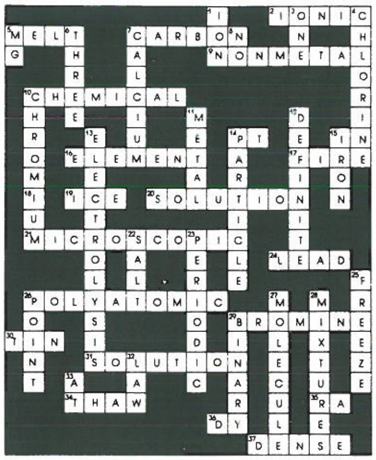
57. (a) 90.4
(b) 53.0991
(c) 7.7×10^{-5}
(d) 4.0076
(e) 1.86[redacted] $\times 10^4$
(f) −0.000 769
(g) 7.002×10^5
(h) −35.55
(i) [redacted] 1.368×10^{-7}
(j) [redacted] 6.21×10^{-9}

58. (a) 8.53 (b) 0.64 (c) −29.7 (d) 4.0×10^2 (e) 1.67×10^4 (f) 30.9 (g) 5.6×10^2 (h) -8.72×10^{-3} (i) 3.1×10^2 (j) 0.004 000

59. (a) 0.856 (b) 102.1 (c) 0.69 (d) 610 (e) −23.9 (f) 96 (g) 1.1 (h) 0.109

DOWN

1. A charged particle
3. Atomic number of hydrogen
4. Element in Group 7
5. Symbol for magnesium
6. Atomic number of lithium
7. Element with symbol Ca
8. Symbol for nobelium
10. Element with symbol Cr
11. Any element in the left or center of the periodic table
12. Law of __________ composition
13. Breakdown of a substance by electricity
14. Any tiny piece of matter
15. Element with symbol Fe
22. Common name for sodium chloride
23. Chart of elements: the __________ table
25. To change from liquid to solid
26. Temperature at which a substance boils: boiling __________
27. Smallest particle of a substance such as water
28. Physical combinations of more than one substance
29. Compound composed of two kinds of atoms
32. Scientific generalization, such as that involving multiple proportions
33. Symbol for astatine



Name ____________________

Class ____________ Date ____________

Numbers Large and Small

A. Scientific Notation

In science, numbers are typically expressed as the product of a number between 1 and 10 and 10 raised to a power. For example, the number 1350 = 1.350×10^3; 0.002 = 2×10^{-3}. Such a way of expressing numbers is much more efficient and also simplifies calculations.

When numbers written in such notation are multiplied, the first factors are multiplied and the exponents of 10 are added. For example, $(2 \times 10^4)(3 \times 10^5) = 6 \times 10^9$. When such numbers are divided, the first factors are divided and the exponent of the 10 in the denominator is subtracted from the exponent of the 10 in the numerator.

For example, $\frac{8 \times 10^7}{2 \times 10^3} = 4 \times 10^4$.

1. Convert the following measured quantities from ordinary notation to scientific notation.

	ORDINARY NOTATION	SCIENTIFIC NOTATION
Mean wavelength of sodium light	0.000 000 5893 meters	5.893×10^7 m
Speed of light in a vacuum	299 793 000 meters/second	$2.997\,93 \times 10^8$ m/s
Half-life of uranium-235	710 000 000 years	7.1×10^8 years
Atomic mass unit	0.000 000 000 000 000 000 000 001 660 531 grams	$1.660\,531 \times 10^{-24}$ g
Avogadro's number	602 300 000 000 000 000 000 000	6.023×10^{23}
Melting point of tungsten	3410°C	3.41×10^3 °C

2. Convert each of the following measured quantities from scientific notation to ordinary notation.

	SCIENTIFIC NOTATION	ORDINARY NOTATION
Mass of an electron	9.109×10^{-31} kg	0.000 000 000 000 000 000 000 000 000 000 9109 kg
Temperature at which atomic fusion occurs	1.5×10^7 °C	15 000 000 °C
Lowest possible temperature	-2.73×10^2 °C	−273 °C
Diameter of the Andromeda galaxy	1.9×10^{18} km	1 900 000 000 000 000 000 km
Radius of a hydrogen energy level	5.3×10^{-11} m	0.000 000 000 053 m
Charge of a proton	1.6×10^{-19} coulomb	0.000 000 000 000 000 000 16 coulomb

3. Express each of the following numbers in scientific notation.

2370	2.37×10^3
0.03	3×10^{-2}
0.000 000 000 000 274	2.74×10^{-13}
985 000 000 000 000 000 000	9.85×10^{20}
15.045	1.5045×10^1
6003	6.003×10^3
0.000 045	4.5×10^{-5}
0.000 000 007 07	7.07×10^{-9}

4. Express each of the following numbers in ordinary notation.

5.63×10^{-3}	0.005 63
6.7×10^5	670 000
1.01×10^3	1010
9.899×10^{-8}	0.000 000 098 99
2×10^6	2 000 000
7.85×10^{-2}	0.0785
3.444×10^{10}	34 440 000 000
2.0002×10^{-4}	0.000 200 02

5. Perform the indicated operations.

$10^3 \times 10^6 =$ 10^9

$\frac{10^2}{10^8} =$ 10^{-6}

$10^{-2} \times 10^5 =$ 10^3

$10^{-1} \times 10^{10} =$ 10^9

$\frac{10^7}{10^3} =$ 10^4

$\frac{10^2}{10^{-5}} =$ 10^7

6. Perform the indicated operations. Convert all answers to scientific notation, showing the correct number of significant digits.

$(5.4 \times 10^2)(2.5 \times 10^9) =$ $13.5 \times 10^{11} = 1.4 \times 10^{12}$

$(1.2 \times 10^{-5})(5.4 \times 10^6) =$ 6. $= 6.5 \times 10^1$

$(3.3 \times 10^{-7})(6.6 \times 10^{-7}) =$ $21.78 \times 10^{-14} = 2.2 \times 10^{-13}$

$(2.56 \times 10^3)(1.00 \times 10^{-1}) =$ $2.56 \times 10^2 = 2.56 \times 10^2$

$7.25\,(5.5 \times 10^{12}) =$ $39.875 \times 10^{12} = 4.0 \times 10^{13}$

$\frac{(1.5 \times 10^7)}{(4.5 \times 10^5)} =$ $0.333\,333 \times 10^2 = 3.3 \times 10$

$\frac{(9.6 \times 10^2)}{(3.2 \times 10^8)} =$ $3.0 \times 10^{-6} = 3.0 \times 10^{-6}$

$\frac{(8.05 \times 10^{-9})}{(5 \times 10^{-4})} =$ $1.61 \times 10^{-5} = 2 \times 10^{-5}$

$\frac{4.5}{(1.38 \times 10^{-3})} =$ $3.26087 \times 10^3 = 3.3 \times 10^3$

$\frac{(2.75 \times 10^9)}{2.5} =$ $1.1 \times 10^9 = 1.1 \times 10^9$

$(3.2 \times 10^5) + (4.5 \times 10^5) =$ 7.7×10^5

$(9.2 \times 10^{-3}) - (5.6 \times 10^{-3}) =$ 3.6×10^{-3}

$(4.33 \times 10^3) + (3.72 \times 10^3) =$ $41.53 \times 10^2 = 4.15 \times 10^3$

$(6.81 \times 10^{-6}) + (8.3 \times 10^{-5}) =$ $89.81 \times 10^{-6} = 9.0 \times 10^{-5}$

$(5.8 \times 10^4) - (6.42 \times 10^4) =$ $-0.62 \times 10^4 = -6 \times 10^3$

$(2.75 \times 10^7) + (5.5 \times 10^8) = 57.75 \times 10^7 =$ 5.8×10^8

$(1.9 \times 10^{-3}) - (1.5 \times 10^{-4}) = 17.5 \times 10^{-4} =$ 1.8×10^{-3}

$(4.3 \times 10^4) - (8.5 \times 10^3) = 34.5 \times 10^3 =$ 3.4×10^4

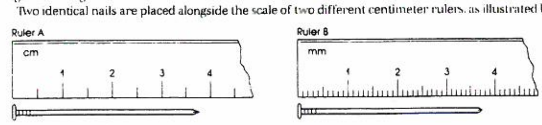
$(8.7 \times 10^3) + (7.9 \times 10^2) = 94.9 \times 10^2 =$ 9.5×10^3

$(6.25 \times 10^4) - (3.5 \times 10^5) = -28.75 \times 10^4 =$ -2.9×10^5

B. Accuracy and Precision

Accuracy is an indication of how close a measured value comes to the true value. Precision refers to the amount of uncertainty in the measurement. A mass reading such as 3.52 g, that has three significant digits, for example, is more precise than a reading such as 3.5 g, that has only two significant digits.

Two identical nails are placed alongside the scale of two different centimeter rulers, as illustrated below.



1. Complete the following chart.

	RULER A	RULER B
Smallest division of ruler	0.5 cm	0.1 cm
Length of nail as measurable on ruler	3.8 cm	3.79 cm
Number of significant digits	2	3
Uncertainty (± cm)	±0.1 cm	±0.01 cm
Relative uncertainty	$\frac{0.1 \text{ cm}}{3.8 \text{ cm}} = 0.0263$	$\frac{0.01}{3.79 \text{ cm}} = 0.002\,64$

2. Ruler B → has more divisions

3. Ruler A → closer to true value.