Significant Figures/Significant Digits for High School Chemistry and Physics Students

This handout is self-guided. The questions are to help you test your knowledge, so the answers are given to you. If you don't know why your significant figures are incorrect, check your math. Still unsure? Ask your tutor or teacher for help.

Significant figures are the same as *significant digits*. Significant figures are often abbreviated as SigFigs in this handout.

You need to understand SigFigs because calculators don't know significant figures. They just give you allllllll the digits they calculated. You need to be smarter than your calculator.

Still confused after completing the worksheet? Check out these websites!

https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Quantifying_Nature/Significant_Digits

https://www.youtube.com/playlist?list=PLvUW25kBaMMs9m0GL4dz8jSs0K4PWfqCp

https://wpsites.ucalgary.ca/chem-textbook/chapter-1-home/significant-figures/

Numbers with Significant Figures

Significant figures tell us how precisely a thing was measured. Time is a *measurable* thing. The number of SigFigs tell you how precisely something like time was measured. If someone told you they took a 3 hour hike, this isn't a particularly precise measurement. (Other things can be measured with different precision – distance, volume, mass, temperature, etc.)

Things also have precision based on what they are calculated from. This is why SigFigs are carried through calculations—you can't be more precise than what you put into the equation. If someone took 15 seconds to tie their hiking boot, it wouldn't make sense to say their hike took 2hr, 59min, 45seconds. However, if you knew they spent an hour taking photos while on the hike, it would be reasonable to say that the hike actually took 2 hours. This should make intuitive sense. SigFigs are the scientific method of dealing with different levels of precision in the world.

Measurable or *measured* things need significant figures. However, there are a few types of numbers that aren't measurable or calculatable and therefore have an infinite number of significant figures.

Numbers with Infinite Significant Figures

The values that are *exact by definition* have an infinite number of significant figures. Conversion factors are an example. There is exactly 1000 mL in a litre. There is exactly 2.54 cm in an inch.

For most equations you see in high school the exponents and roots in equations are exact numbers, with infinite Sig Figs. The major exception to this rule is chemistry for pH and pOH, discussed in the section on logarithms.

The final type of numbers that have as many significant figures as you need are *countable numbers*. If there are 4 people in the car, that can be exactly counted – there aren't 3.5 people in the car (if you cut a person in half, they stop being a person). So, in this case the number 4 has an infinite number of significant figures because it is countable.

There are limits to countability! As a guideline, if you can reasonably expect an individual to count the items without losing track, the number is countable. If there are 6 people living in a house, that is countable. However, if there are 561 004 people living in a city, it would be practically impossible for one individual to accurately count that many people. If they went door-to-door, some people would not be home. The number of people would also fluctuate due to births and deaths between the start and end of the census. It is impractical for one individual to keep track, therefore a census result does have SigFigs.

Examples of *countable* numbers with infinite significant figures

Chemistry & Physics

Charge on ions. A Cu^{2+} ion has lost exactly two electrons.

Number of protons, neutron, and electrons in an atom. For carbon-13 ($^{13}_{6}\mathrm{C}$) the numbers shown are exact.

Chemistry

In chemical equations, all the numbers in chemical equations are countable

$$2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(g)}$$

Here, two molecules of hydrogen react with exactly one molecule of oxygen. Water contains exactly two hydrogen atom and one oxygen atom.

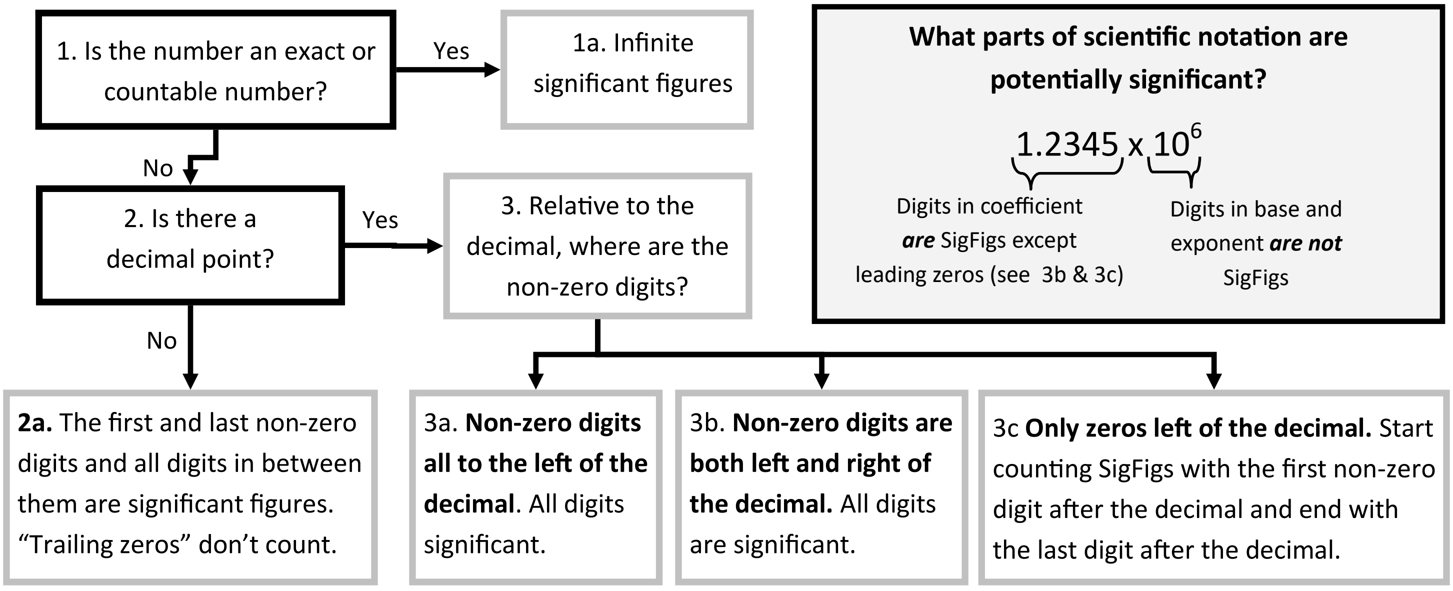
Fractional balancing coefficients are often seen in college and university chemistry courses. The ratio between reactants and products is what is exact, so in

$$H_{2(g)} + ½\ O_{2(g)} \rightarrow H_2O_{(g)}$$

the coefficient of 1/2 has an infinite number of SigFigs.

Determining what Digits are Significant

- All non-zero digits and zeros occurring between non-zero digits are significant.
- If not all zeros occur between non-zero digits, follow the chart to determine what is significant.



What parts of scientific notation are potentially significant?

$$\underbrace{1.2345}_{\substack{\text{Digits in coefficient} \\ \textbf{\textit{are}}\text{ SigFigs except} \\ \text{leading zeros (see 3b \& 3c)}}} \times \underbrace{10^{6}}_{\substack{\text{Digits in base and} \\ \text{exponent }\textbf{\textit{are not}} \\ \text{SigFigs}}}$$

Examples of counting significant figures

$\underbrace{205}_{\text{Sig Figs}}\underbrace{00}_{\text{Trailing zeros}}$	In whole numbers when there is no decimal the significant figures do not include “trailing zeros.” In other words, the zeros that are not surrounded by digits are not significant. This example has 3 SigFigs. (Example of 2a.) Some people believe the decimal is implied. To avoid confusion, I recommend writing values with trailing zeros in scientific notation.
$\underbrace{1050.}_{\text{Sig Figs}}$	Since this has a decimal place, all the digits are significant. Again, it is easy to confuse the decimal with a period when written in a sentence, so I tend to write a value like this using scientific notation. 4 SigFigs, like below. (Example of 3a.)
$\underbrace{1.050}_{\text{Sig Figs}} \times \underbrace{10^3}_{\text{Base \& exponent}}$	Now we know exactly how many digits are significant. There are 4 SigFigs (the base and exponents of the scientific notation are not significant figures) (Example of 3b.)
$\underbrace{10.2}_{\text{Sig Figs}}$	All the numbers in this example are significant. This number has 3 SigFigs. (Example of 3b.)
$\underbrace{0.000}_{\text{Leading zeros}}\ \underbrace{470\ 220}_{\text{Sig Figs}}$	All numbers after both a decimal and a non-zero digit are significant. Leading zeros are not significant. This example has 6 SigFigs. (Example of 3c.)
$\underbrace{0}_{\text{Leading zero}}\underbrace{102.}_{\text{Sig Figs}}$	…I’m not sure why you are writing the number like this, but ok… I guess we will call those leading zeros, which are not significant. This number has 3 SigFigs. Please re-write it as 102 or 1.02×10^2 to avoid confusion. (No respectable number would let itself be seen like this. It should not be an example for anything.)

You should now be able to solve questions 1-10

We usually need to perform calculations with numbers. Which significant figures are important changes depending on what type of mathematical operations we are performing on the numbers.

For high school science courses, we can sort the mathematical operations into four groups:

- addition & subtraction
- multiplication & division
- logarithms, exponents, antilogarithms, roots
- trigonometric functions (high school physics)

Addition and Subtraction

For addition and subtraction, the number of SigFigs *after the decimal place* in the result of your calculation is the same as the smallest number of after-decimal SigFigs in the original numbers.

0.002	3 SigFigs **after the decimal**
+ 10.0	1 SigFig **after the decimal (smallest)**
$\underbrace{10.0}_{\text{Sig Figs}}02$	The answer has 1 SigFig **after the decimal**. Correct SigFigs answer: 10.0

However, you *can* gain or lose significant figures *before* the decimal place.

100.0	1 SigFig **after the decimal (smallest)**
- 8.0001	4 SigFigs **after the decimal**
$\underbrace{91.9}_{\text{Sig Figs}}999$	Rounded to correct SigFigs, answer is 92.0 – less SigFigs than the original numbers, but the same number of SigFigs **after the decimal!**

If you are adding or subtracting more than two numbers, the fewest number of SigFigs after the decimal wins.

0.29	2 SigFigs **after the decimal**
0.437	3 SigFigs **after the decimal**
+ 12.0	1 SigFig **after the decimal (smallest)**
$\underbrace{12.8}_{\text{Sig Figs}}67$	Rounded to correct SigFigs, answer is 12.9 – the same number of SigFigs **after the decimal!**

When adding and subtracting quantities with different units or unit prefixes, or scientific notation bases, convert so are all the same.

- $41.0 + 1.7 \times 10^2$ have different exponents. Convert to $(0.410 + 1.7) \times 10^2$ or $41.0 + 170$, then add. $(0.410 + 1.7) \times 10^2 = 2.1 \times 10^2$.
- 73g + 1.096kg have different unit prefixes. Add when both are either in g or kg. (73g + 1.096kg = 73g + 1096g = 1169g)
- 6.00hr – 15min. Convert to same units and solve. (5.75hr, 5hr:45min, or 345 min all have the same SigFigs)

You should now be able to solve questions 11-20.

Converting to the same scientific notation exponent

First, decide which base you want to convert to. Then, multiply each number not in that base by base/base:

$$\left(\frac{41.0)}{10^2}\right)(10^2) + 1.7 \times 10^2$$

$$= (0.410 \times 10^2) + 1.7 \times 10^2$$

$$= (0.410 + 1.7) \times 10^2$$

Multiplication and Division

When multiplying and dividing, the result will have the lowest number of SigFigs from the numbers you multiplied or divided.

17 x	10.000 001 =	170.000 017	Answer with correct SigFigs: 1.7×10^2 or 170
2 SigFigs (Lowest)	8 SigFigs	Incorrect SigFigs	Both answers have the correct SigFigs, but the scientific notation one is much clearer.

If you are multiplying or dividing more than two numbers, the lowest number of SigFigs controls the number of SigFigs in your answer.

Unlike with addition, when multiplying and dividing you don't need to make sure the unit prefix or scientific notation exponent match.

You should now be able to solve questions 21-30.

The number of brackets you may need to include with long strings of multiplication and division when typing numbers with scientific notation into a calculator makes it very easy to forget a closing bracket, and most calculators will not give you an error message if you forget one. To avoid errors when typing into a calculator while only multiplying and dividing numbers, I prefer to cancel prefixes and deal with the scientific notation on paper or in my head.

For example, if you simply cancel ~~m~~mol/~~m~~L = mol/L, you no longer need to convert mmol to mol or mL to L. Fewer calculations = fewer chances for mistakes.

Similarly, you can reduce the things you must type into a calculator by mentally adding or subtracting the exponents like this: $(8.0 \times 10^4)(1.5 \times 10^2) = (8.0 \times 1.5)(10^{4+2}) = 12 \times 10^6 = 1.2 \times 10^7$.

Logarithms, Exponents/Antilogarithms, and Roots

"Antilog" is just another way to say "exponent." "Roots" are really just fractional exponents ($\sqrt{x} = x^{1/2}$).

$\log_b(a)=e$

$b^e = a$

a is the *argument*

e is the *exponent*

b is the mathematical *base.* If no number is written as a subscript in the logarithm, the base is 10.

(Technically, the rules for SigFigs for logarithms with bases other than 10 *can* be different. However, I didn't need to worry about other bases than 10 until my upper-level university science courses.)

For most roots and exponents, we use the same rules as multiplication and division. The result of X^3 will have the same number of significant figures as X did. The result of $\sqrt{z}$ will have the same number of SigFigs as *z.* The result of $q^{1/4}$ will have the same number of SigFigs as *q.* **Unless you are dealing with pH, pOH, or another situation where you know that the roots and exponents are not exact, assume that the number of significant figures in the argument of the root or expoenent will be the same as the mathematical base had.**

When you take the logarithm, you need to stop and think. Similarly, if the exponent you need to apply to the base is not an exact number, you need to think.

For high school, the most likely place for you to encounter this is in calculating pH or pOH from concentrations.

In the equation $[H^+] = 10^{-pH}$, the argument is $[H^+]$ (the concentration of hydrogen ions in solution), the exponent is -pH, and the mathematical base is 10.

To determine the number of SigFigs in an argument, we count them normally.

However, *only the numbers after the decimal are significant* in the exponent.

$$pH = -\log[H^+] = -\log(4.0 \times 10^{-10}\ mol/L)$$

There are 2 SigFigs in the argument of 4.0×10^{-10} mol/L. So, the value of the pH (the exponent) will have 2 SigFigs *after the decimal.* To correct SigFigs, the pH is 9.15.

Similarly, if we have a pH of 14.000, there are three figures *after the decimal* in the exponent. The concentration (the argument) will have three SigFigs total.

$$[H^+] = 10^{-pH} = 10^{-14.000} = 1.00 \times 10^{-14}\ mol/L$$

You should now be able to solve questions 27-40.

Note: if a pH is given with no digits after the decimal this technically means it has no significant figures. (So, a pH of 7 would have a $[H^+]$ of 10^{-7} mol/L.) In the real world, even people who remember this rule will sometimes incorrectly write a one SigFig concentration (1×10^{-7} mol/L).

Trigonometric Functions

When using trig functions, you have the same number of significant figures that you put into the equation in the result.

Example: $\cos(38.1°) = 0.786$

Example: $\sin^{-1}(0.30) = 17°$

You should now be able to solve questions 41-44.

Calculations Involving Multiple Types of Math

In math, you were likely taught to do calculations in the following order, often remembered as BEDMAS, which is a simplification of the more complex rules mathematicians use:

1. Complete everything within **Brackets**.
2. Complete all **Exponents,** roots (which are fractional exponents), and logarithmic calculations.
3. Complete all **Division** and **Multiplication** (left to right as written).
4. Complete all **Addition** and **Subtraction** (left to right as written).

After each step, you will need to record or remember the correct number of SigFigs in the result of the calculation.

Brackets and invisible brackets

Remember: "complete everything in brackets" means you apply the order of operations to the contents of the brackets. If there are nested bracket, you complete the inner most ones first (work from the inside of the onion, and try not to cry!)

There are also "invisible" or implied brackets.

In the equation at the right, there are two sets—you complete the subtraction on the top and the addition on the bottom before dividing the results. Written on one line, it would be: (A - B)/(C + B)

$$\frac{A-B}{C+B}$$

There are also invisible brackets in 2^{3^4}

With the visible brackets, it would read $2^{(3^4)}$

Similarly, Q^{x+y} has invisible brackets: $Q^{(x+y)}$

<u>Keep all digits in your calculator until the final step to avoid rounding errors!!!!!!</u>

Rounding errors

Rounding errors are what happens if you don't keep all the digits in your calculator (or at least, you don't keep *enough* digits in your calculator).

Example:

Rounded after each step	Rounded only after the final step
$3.0-\left(\frac{245}{1.0 \text{ x } 10^2}\right)$	$3.0-\left(\frac{245}{1.0 \text{ x } 10^2}\right)$
= 3.0 – 2.5	= 3.0 – 2.45
= 0.5	= 0.55 incorrect SigFigs
	=0.6 rounded to correct SigFigs

These are very different answers.

In high school for graded assignments and work, I recommend you write out something like "incorrect SigFigs" and "rounded to correct SigFigs."

Rounding

There are a few different rules on how numbers should be properly rounded. The rounding rules used in this handout are as follows:

First digit to be rounded is 0-4: round down.

First digit to be rounded is 6-9: round up.

First digit to be rounded is 5, and there are more non-zero digits after it: round up. (0.551 → 0.6)

Digit to be rounded is exactly 5: round to have an even terminal number. (0.55 → 0.6 *and* 0.65 → 0.6).

However, working scientists really don't want to write out 6 extra words. Many scientists keep extra by writing out the non-significant numbers we are keeping around for calculation purposes as subscripts. The above example would look something like this:

$$3.0-\left(\frac{245}{1.0 \text{ x } 10^2}\right)=3.0-\ 2.4_5=0.5_5=0.6$$

This is a perfectly acceptable way for you to keep track of SigFigs for ungraded work and when doing calculations for multiple choice or numeric response questions on tests.

You will often wish to carry more than one non-significant figure for your calculations. This is normal, and in many cases necessary.

If there are more than one or two extra digits you wish to keep around for calculations, it is rare that you will need more than 4 non-significant digits to avoid rounding problems.

For scientific notation, carrying extra digits looks like this:

$$4.0_{1576} \text{ x } 10^{4} \text{ kJ}$$

Multi-step calculations example

Find the non-negative value of x

$$\frac{x^2}{0.150 - x} = 1.6 \text{ x } 10^{-2}$$

Algebra to rearrange the equation into a solvable form

$$(1.6 \text{ x } 10^{-2})(0.150 - x) = x^2$$

$$0 = x^2 - (1.6 \text{ x } 10^{-2})(0.150) - (1.6 \text{ x } 10^{-2})(-x)$$

$$0 = x^2 + (1.6 \text{ x } 10^{-2})x - 2.4_0 \text{ x } 10^{-3}$$

You don't need to carry terminal non-significant zeros, but you can if you want to.

Using the quadratic formula,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, a = 1\ (exact), b = 1.6 \text{ x } 10^{-2}, c = -2.4_0 \text{ x } 10^{-3}$$

If no co-efficient is written, it's implied to be 1 with infinite SigFigs. The 4 & 2 in the formula are exact numbers with infinite SigFigs.

There are invisible brackets in the quadratic equation. If we wrote out the invisible brackets, it would look like this:

$x = (-b \pm (b^2 - 4ac)^{\frac{1}{2}})/(2a)$

We don't always do this. As formulas get more complex, they need more brackets, which can be confusing. This equation has only a few invisible brackets: everything under the square root, the top, and the bottom.

$$x = \frac{-(1.6 \text{ x } 10^{-2}) \pm \sqrt{(1.6 \text{ x } 10^{-2})^2 - 4(1)(-2.4_0 \text{ x } 10^{-3})}}{2(1)}$$

$$x = \frac{-1.6 \text{ x } 10^{-2} \pm \sqrt{2.5_6 \text{ x } 10^{-4} + 9.6_0 \text{ x } 10^{-3}}}{2}$$

The full sized numbers in the coefficients are significant. The subscript numbers are typed into the calculator to avoid rounding errors.

$$x = \frac{-1.6 \text{ x } 10^{-2} \pm \sqrt{2.5_6 \text{ x } 10^{-4} + 96._0 \text{ x } 10^{-4}}}{2}$$

$$x = \frac{-1.6 \text{ x } 10^{-2} \pm \sqrt{98._{56} \text{ x } 10^{-4}}}{2}$$

$$x = \frac{-1.6 \text{ x } 10^{-2} \pm 9.9_{277} \text{ x } 10^{-2}}{2}$$

Numbers in scientific notation are converted to the same base so we can see what is significant for addition. Fortunately, the square root has the same base as –b, so we didn't need to convert before the final addition/subtraction.

We only need the positive value of x.

$$x = \frac{8.3_{277} \text{ x } 10^{-2}}{2} = 4.1_{639} \text{ x } 10^{-2}$$

To correct # of SigFigs, $x = 4.2 \text{ x } 10^{-2}$

If we strictly followed BEDMAS order of operations, the calculations should have been completed following the order on the right. However, I completed steps 1, 2, and 6 at the same time.

My experience tells me that the answer to step 1 does not affect the answers to steps 2 and 6, etc. I do them all at the same time to minimize the risk of copying down the wrong information for the next step of showing my work—and to make copying faster. There are a number of other ways to correctly show you work. With experience, you will figure out which steps you can and should combine to show your work as efficiently as possible, and still make certain you get your significant figures correct.

$$x = \underbrace{(\underbrace{-b \pm \overbrace{(\overbrace{\overbrace{b^2}^{1.} - \overbrace{4ac}^{2.}}^{3.})^{\frac{1}{2}}}^{4.}}_{5.})/(\underbrace{2a}_{6.})}_{7.}$$

You should now be able to solve questions 45-60.

Questions

How many significant figures are in the following numbers?

1. 0.0205
2. 800.
3. 0.15
4. 2.1×10^{-7}
5. 4242 mL
6. 0.000 796 20
7. 10.10×10^{8}
8. 0.023×10^{7}
9. 0.000 100 100
10. 737 600 km

Solve

11. $10.7 + 42$
12. $100.1 – 0.9001$
13. $15.999 + 1.01 + 22.99$
14. $707.2 + 12.001 - 700$
15. 22.2 m + 195 cm
16. -1745.0 kJ/mol + 793.0 J/mol
17. $0.0500 – 1.7 \times 10^{-2}$
18. $1.42 \times 10^{3} + 2.3 \times 10^{4}$
19. $-1.500 \times 10^{-10} + 7.6 \times 10^{-12}$
20. 2.7×10^{2} °C – 25.0°C

21. $210(-1.500 \times 10^{-10})$
22. (100.1 mg)/(195 mL)
23. $(2.32 \times 10^{7})(7.6 \times 10^{-12})$
24. $(1.7 \times 10^{-2})/42.42$
25. $(100.1)(0.9001)/(1.42 \times 10^{3})$
26. $(2.1 \times 10^{-7})(1.42 \times 10^{3)}/((12.001)(1.42))$

Solve

27. $(17.2)(2.3 \times 10^{4})/(97.34)^{2}$
28. $(31.97 \text{ m/s})^{2}/(679 \text{ m})$
29. $(1.7 \times 10^{-2})^{2}/\sqrt{(29.3)}$
30. $(7.6 \times 10^{-12})^{2}/(2.32 \times 10^{-7})^{3}$

Complete the table

	pH	$[H^+]$		pOH	$[OH^-]$
31.		7.07×10^{-3} mol/L	**36.**	13.1	
32.	9.111		**37.**		0.0500 mol/L
33.		1.0 mol/L	**38.**	2.62	
34	4.2		**39.**		2.9×10^{-5} mol/L
35.		2×10^{-10} mol/L	**40.**	7	

(Remember: $pH = -\log [H^+]$, $pOH = -\log [OH^-]$)

Solve. All answer angles are in °

41. sin(1°)
42. $\cos^{-1}(0.23)$
43. $\sin^{-1}(-0.9009)$
44. cos(370°)

Solve

45. $\frac{(6.09 \text{ x } 10^{-15})+(8.017 \text{ x } 10^{-14})}{27.30}$

46. $(6.677 \text{ x } 10^{-2})(1.8 \text{ x } 10^{11}) - (4.349 \text{ x } 10^{3})(2.98 \text{ x } 10^{6})$

47. $\frac{8.37 \text{ x } 10^{9}+9.57 \text{ x } 10^{10}}{5.25 \text{ x } 10^{8}} + 143.479$

48. $(49.3 + 57.66)(37.60 – 9.1)$

49. $0.3397 \frac{1.20 \text{ x } 10^{3}-8.33 \text{ x } 10^{2}}{9.42 \text{ x } 10^{-2} + 7. \text{ x } 10^{-1}} - 100.63$

50. $1.99(8.199 \text{ x } 10^{-2})(1.297 - 0.83)^{2}$

51. $\frac{(1.33 \text{ x } 10^{-2})(0.703+0.320)}{(6.007\text{x } 10^{6})^{2}} - 2.3105 \text{ x } 10^{-14}$

52. $(29.75)10^{7.25}$

53. $\left(\frac{13.007-6.283}{13.007}\right)(9.023 \text{ x } 10^{12} - 7.9 \text{ x } 10^{10})$

54. $\frac{250.6-197.32}{822.9 +197.32}$

55. $0.23(2.06 \text{ x } 10^{-7}) + 0.198(9.97 \text{ x } 10^{-6}) + 0.572(1.81 \text{ x } 10^{-8})$

56. $\log(8.76 \text{ x } 10^{6}) + \log(4.6 \text{ x } 10^{16})$

57. (725 m) sin (27°)

58. Chemistry: what is the molar mass of sodium sulphate, given M_{Na}= 22.99 g/mol, M_S = 32.059 g/mol, and M_O = 15.999 g/mol?

59. Chemistry: What is the concentration of NaOH in the solution that results when a container with 10.00mL of NaOH at a pOH 4.25 is mixed with a container of 150.0 mL of NaOH solution with a pOH of 1.07?

60. Physics: what is the acceleration of a vehicle whose velocity changes from 30.2 m/s forward to 3.22 m/s reverse in 5.0 seconds? Recall $a = \frac{v_f - v_i}{t}$.

Answers

1.	3	**13.**	40.00	**25.**	0.0635	**37.**	1.301	**49.**	$6 \text{ x } 10^{1}$
2.	3	**14.**	$2 \text{ x } 10^{1}$ **	**26.**	$1.7 \text{ x } 10^{-5}$	**38.**	$2.4 \text{ x } 10^{-3}$ mol/L	**50.**	0.036
3.	2	**15.**	24.2 m ***	**27.**	42	**39.**	4.54	**51.**	$-2.2728 \text{ x } 10^{-14}$
4.	2	**16.**	-1744.2 kJ/mol *OR* $-1.7442 \text{ x } 10^{6}$ J/mol	**28.**	1.51 m/s^{2}	**40.**	10^{-7} mol/L	**52.**	$5.3 \text{ x } 10^{8}$
5.	4	**17.**	$3.3 \text{ x } 10^{-2}$	**29.**	$5.3 \text{ x } 10^{-5}$	**41.**	$2 \text{ x } 10^{-2}$	**53.**	$4.624 \text{ x } 10^{12}$
6.	5	**18.**	$2.4 \text{ x } 10^{4}$	**30.**	$4.6 \text{ x } 10^{-3}$	**42.**	77°	**54.**	0.0522
7.	4	**19.**	$1.424 \text{ x } 10^{-10}$	**31.**	2.151	**43.**	-64.28°	**55.**	$2.03 \text{ x } 10^{-6}$
8.	2	**20.**	$2.4 \text{ x } 10^{2}$ ***	**32.**	$7.74 \text{ x } 10^{-10}$ mol/L	**44.**	0.98 **	**56.**	23.61
9.	6	**21.**	$-3.2 \text{ x } 10^{-8}$ **	**33.**	0.00	**45.**	$3.160 \text{ x } 10^{-15}$	**57.**	$3.3 \text{ x } 10^{2}$ m
10.	4 ***	**22.**	0.513 g/L	**34.**	$6 \text{ x } 10^{-5}$ mol/L	**46.**	$-9 \text{ x } 10^{8}$	**58.**	142.04 g/mol
11.	53	**23.**	$1.8 \text{ x } 10^{-4}$	**35.**	9.7	**47.**	342	**59.**	0.80 mol/L
12.	99.2	**24.**	$4.0 \text{ x } 10^{-4}$	**36.**	$8 \text{ x } 10^{-14}$ mol/L	**48.**	$3.05 \text{ x } 10^{3}$	**60.**	-6.7 m/s^{2} or 6.7 m/s^{2} reverse

Hints: **Review rule 2a. ***Review rounding rules on page 6.