

Student Name: _____

Chemistry Summer Math Prep Packet

Dear Future Chemistry Student,

Welcome! If you are working through this packet, it means you are getting ready to take chemistry. While it is exciting, it can also feel a little intimidating.

Many students think chemistry is hard because of the science, but often the most difficult part is actually the math. Chemistry uses many of the math skills you have already learned in middle school and Algebra 1. You will need to use calculators correctly, read graphs, work with decimals, solve equations, use fractions, and set up proportions.

The good news is that you do not need to be “good at math” to be successful in chemistry. **You just need practice.**

The purpose of this packet is to help you review and strengthen the math skills that will appear over and over again in chemistry class. The packet starts with easier skills and slowly builds to harder ones. Each section includes a short reading, examples, and practice questions. By the end, you will complete a review that mixes all of the skills together.

As you work, do not worry if you make mistakes. **Mistakes are part of learning.** If you get stuck, slow down, reread the directions, and try again. The more you practice now, the more confident you will feel when chemistry begins.

You can do this! Good luck, and have fun getting ready for chemistry!

- Your Future Chemistry Teacher

This packet is due on: _____

It will be graded: _____

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1: Calculator Skills

A calculator is a tool, but it only works correctly when you know how to enter the problem the right way. In chemistry, you may need to type in long calculations with fractions, parentheses, scientific notation, and several operations all at once. If you enter the numbers incorrectly, your answer will be wrong **even if you understand the science perfectly!**

Order of Operations

The most important rule when using a calculator is to remember **order of operations**. Calculators solve problems in this order:

- Parentheses
- Exponents
- Multiplication and Division (from left to right)
- Addition and Subtraction (from left to right)

For example, in the problem $3 + 4 \times 2$, the calculator multiplies first, which works in accordance with the Order of Operations:

Step 1) $4 \times 2 = 8$

Step 2) $3 + 8 = 11$

If you worked from left to right, you'd have:

Step 1) $3 + 4 = 7$,

Step 2) $7 \times 2 = 14$

Many students make mistakes because they forget to use parentheses. Parentheses tell the calculator which part to do first.

Compare these two problems:

$$5 + 3 \times 2 = 11$$

$$(5 + 3) \times 2 = 16$$

The numbers are the same and written in the same order, but the answer changes because the **parentheses change the order!** Parentheses are especially important in chemistry when you are dividing by more than one number or subtracting inside a formula.

Sometimes it is easier to type the entire problem into the calculator at once, especially if you use parentheses correctly. However, **if the problem is very long or has several steps, it can be helpful to solve one part at a time and write down the result before continuing.** Breaking the problem into smaller pieces can help you catch mistakes and understand what the calculator is doing instead of simply trusting the final answer.

Scientific Notation

Another important calculator skill is using the scientific notation button. Most calculators have a key labeled $\boxed{\text{EXP}}$ $\boxed{\text{EE}}$ or $\boxed{\times 10^\wedge}$. This button means “times ten to the ____.” It saves time and prevents mistakes when working with very large or very small numbers.

For example:

4.5×10^6 should be entered as 4.5 EXP 6

3.2×10^{-4} should be entered as 3.2 EXP -4

Depending on where a number written in scientific notation appears in an equation, it is often best to place that quantity inside parentheses. This helps ensure that the $\times 10^\wedge$ part applies only to that number and not to any other part of the calculation.

Checking your Answers

Before trusting any calculator answer, pause and ask yourself: “Does this answer make sense?” A calculator is helpful, but **your brain should always stay in charge.**

When solving for variables in a mathematical equation, you should be able to plug your answers back in to check your work!

Practice

1) $9 + 3 \times 3$

2) $(5 + 3) \times 8$

3) $(62.93 \times 0.6917) + (64.93 \times 0.3083)$

4) $1.48 / (0.08206 \times 350)$

5) $(40.08 \times 1) + (19.00 \times 2)$

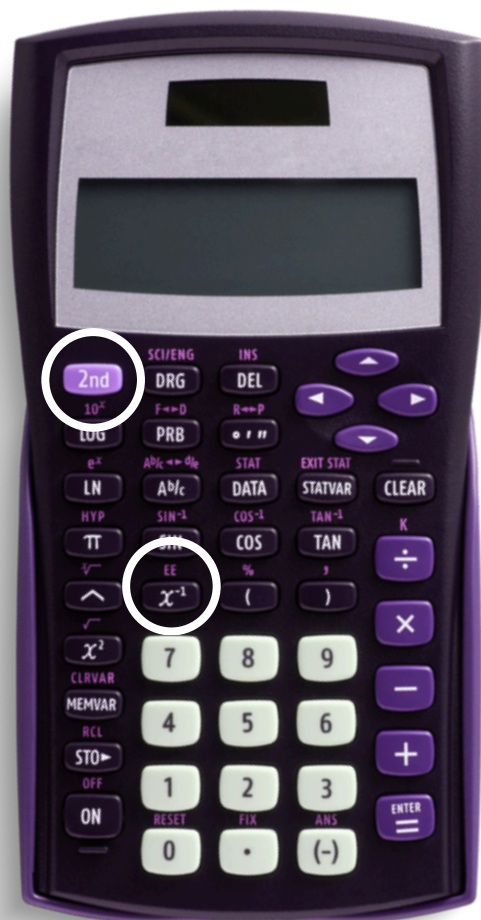
6) $3 \times 10^8 \div 1.14 \times 10^{14}$

7) $100 \times 4.18 \times (25.6 - 22.0)$

8) $(2.0 \times 2.5) \div 1.75$

9) $(6.02 \times 10^{23}) \times 2.8$

10) $(39.10 \times 2) + 32.06$



To use the function on the TI scientific calculators that are written on the calculator and not on the button, you need to press the 2nd button, to get the second function of the button.

2: Graphing

Graphs help scientists organize information and look for patterns. In chemistry, scientists often collect data during an experiment. They may measure temperature, time, mass, volume, or pressure among other things. A graph makes it easier to see how those values change and are related to each other.

Types of Graphs

There are several common types of graphs, and each one is used for a different purpose.

A **bar graph** compares different categories. For example, you might use a bar graph to compare how many students chose chemistry, biology, or physics as their favorite science class.

A **line graph** shows change over time. Line graphs are useful when data is collected in order, such as every minute or every day. For example, a line graph could show how the temperature of water changes as it is heated.

A **scatter plot** shows the relationship between two variables. Scientists use scatter plots when they want to know whether one thing affects another. For example, you could make a scatter plot to see if the number of hours studied affects test scores.

Parts of a Graph

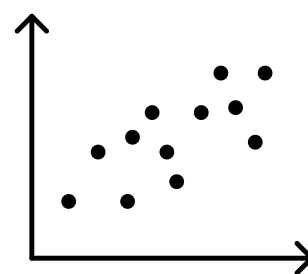
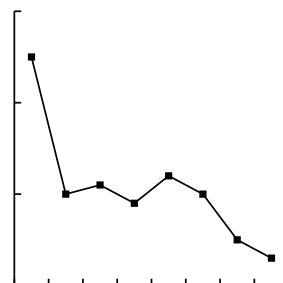
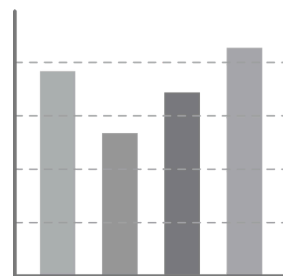
Every graph should have four important parts: a title, an x-axis label, a y-axis label, and a scale.

The x-axis is the horizontal axis. The independent variable goes on the x-axis. This is the thing you choose or change.

The y-axis is the vertical axis. The dependent variable goes on the y-axis. This is the thing you measure.

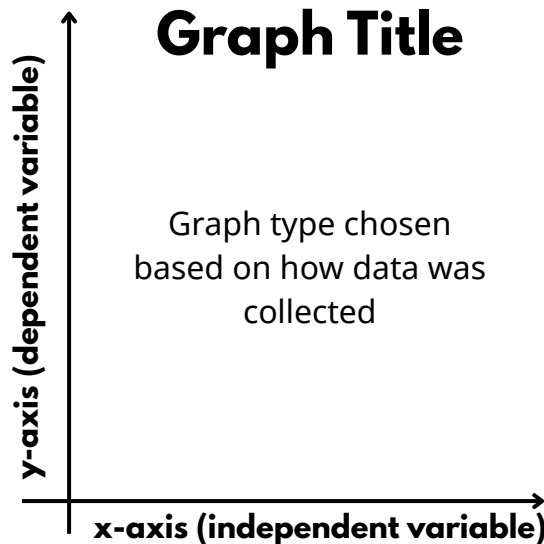
Suppose a student wants to know if studying more causes higher test scores:

- Hours studied = independent variable = x-axis
- Test score = dependent variable = y-axis



Graph Title

Graph type chosen
based on how data was
collected



It is also important to choose a good scale. If your graph jumps by 1, 5, 10, or 100, it should make sense for the data you collected. A poor scale can make the graph difficult to read.

When you look at a graph, **ask yourself what the graph shows and whether the data goes up, down, or stays the same.** The purpose of a graph is not just to make the data look nice. **A graph helps you understand what the data means.**

Practice

- 1) What are the four things every graph should have?

- 2) A graph shows time on the x-axis and temperature on the y-axis. What does the graph help you understand?

- 3) Choose the best type of graph for each scenario:
 - a) showing how reaction temperature changes over time

 - b) comparing favorite color of students in your science class

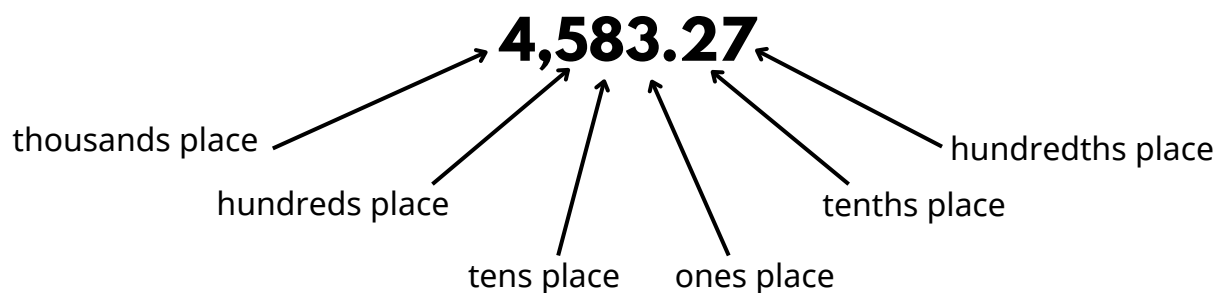
 - c) showing the relationship between practice time and number of home runs

3: Number Basics

Before you can solve chemistry problems, you need to understand how numbers work. Chemistry uses many different kinds of numbers, including decimals, percentages, large numbers, and tiny numbers. If you are comfortable with basic number skills, the chemistry will feel much easier.

Place Value

One important skill is understanding place value. Place value tells you what each digit is worth.



Knowing place value helps when you round numbers or move the decimal.

Moving the Decimal

Moving the decimal is another skill used often in chemistry. When you multiply by 10, the decimal moves one place to the right, making the number larger. When you divide by 10, the decimal moves one place to the left, making the number smaller. Any time you move the decimal and you are left with an empty space, fill it with a zero. For example,

$$4.7 \times 10 = 47$$

$$4.7 \div 10 = 0.47$$

$$3.2 \times 100 = 320$$

$$3.2 \div 100 = 0.032$$

Percentages, Decimals & Fractions

Percentages, decimals, and fractions are also closely related. A percent means “out of 100.” To change a percent into a decimal, move the decimal two places to the left. That’s the equivalent of dividing by ten twice. To change a decimal to a percent, you move the decimal two places to the left. For example,

$$35\% = 0.35$$

$$68.3\% = 0.683$$

$$0.42 = 42\%$$

$$0.125 = 12.5\%$$

To convert a fraction to a decimal divide the numerator (the number on top) by the denominator (the number on the bottom). If you’re unsure, use your calculator. Once you have that number as a decimal, you can convert it to a percent, just like you learned above, by moving the decimal.

For example: $\frac{3}{4} \rightarrow 0.75 \rightarrow 75\%$

It is rare that we want a number as a fraction in chemistry. Most often when we have fractions, we will need them converted into decimals instead.

You will use these conversions often in chemistry, especially when working with percentages, concentration, half lives, isotopes, and lab data. The more quickly you can move between fractions, decimals, and percentages, the easier later chemistry topics will become.

Practice

1) In the number 7,294.63, what digit is in the:

a. Hundreds place

b. Tenths place

c. Ones place

2) Move the decimal:

a. 5.62×10

b. 5.62×100

c. $5.62 \div 10$

d. $5.62 \div 100$

3) Convert:

a. 45% to a decimal

b. 0.18 to a percent

c. 75% to a fraction

d. 0.5 to a fraction

4) Write $\frac{6}{8}$ as:

a. A decimal

b. A percent

4: Rounding

In chemistry, your answer does not need to have every digit. You often round numbers so they are easier to use. In fact, there are times where you will be **required** to reduce the number of digits in your answers.

Basic Rounding Rules

If you are required to “round to the tenths place,” the last digit in your answer should be in the tenths place. In order to round you check the digit **behind** the digit you are rounding to. In this case, you’d check on the hundredths place.

- If the next digit is 5 or greater, round up.
- If then next digit is 4 or less, keep the number the same

For example:

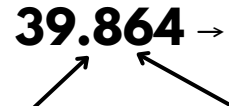
$4.66 \rightarrow 4.7$



tenths place one place back

6 is larger than 5, so the 6 will bump up to a 7

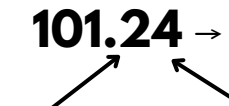
$39.864 \rightarrow 39.9$



tenths place one place back

6 is larger than 5, so the 8 will bump up to a 9

$101.24 \rightarrow 101.2$



tenths place one place back

4 is smaller than 5, so the 2 will stay the same

Estimation

It is important to have a general idea of what your answer should be. Much like when you are shopping. If you buy 3 shirts at \$17.99, you should have in your mind that your total will be close to \$60.

Each shirt is \$17.99, for the purposes of estimation, you could say, “Each shirt cost just under \$20.” This allows you to do mental math much more easily. 20×3 is much simpler than $\$17.99 \times 3$!

The same rules apply in chemistry. When you are able to round to a simpler mental math number, you can better ensure that you’ve punched all the numbers into your calculator correctly. If your answer is wildly off for your estimation, you will know that something went wrong and you should redo your calculator entry. Perhaps you’ve forgotten a negative sign, or missed parentheses in your order of operations.

Practice

1) Round to the nearest whole number:

a. 6.723

b. 12.20

c. 8.5

2) Round to the nearest tenth:

a. 3.4632

b. 9.9257

c. 7.15

3) Estimate:

a. 19×5

b. $198 \div 2$

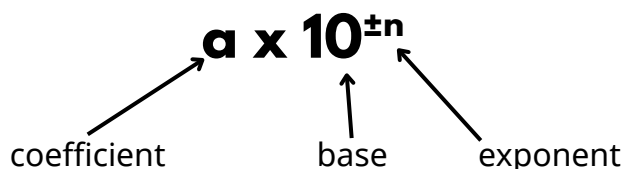
c. $502 + 97$

4) Why is estimation helpful when using a calculator?

5: Scientific Notation

Scientists often work with very large and very small numbers. Scientific notation makes these numbers easier to write, with fewer errors. A commonly used value in chemistry is called “a mole” which represents a quantity of atoms. That number is best written as 6.02×10^{23} since the standard notation is 602,000,000,000,000,000,000. Putting that many zeroes into the calculator can be a recipe for disaster. Refer back to section 1 on Calculator skills for more on how to put these types of numbers into the calculator.

Decoding Scientific Notation



- The **coefficient** needs to be between 1 and 10.
- The base of 10 tells you that you are working with the standard place value.
- The exponent tells you the number of times to move the decimal.
- Whether or not the decimal is positive or negative indicates if the standard notation number is larger or smaller than 1.

$$45,000 = 4.5 \times 10^4$$

The exponent here is positive 4. That means that the standard notation number is greater than 1. It also means, you move the decimal 4 times to get from the scientific notation coefficient to the standard notation number.

$$0.0032 = 3.2 \times 10^{-3}$$

The exponent here is negative 3. That means that the standard notation number is less than 1. It also means, you move the decimal 3 times to get from the scientific notation coefficient to the standard notation number.

Negative Numbers vs. Negative Exponents

If you were working with a negative number, like -68,000, that negative sign would be paired with the coefficient, not the exponent, making -6.8×10^4 . This is a common misconception with students. Be mindful of the location of the negative signs when using scientific notation.

Practice

1) Write in scientific notation:

a. 3,400

b. 78,000,000

c. 0.0045

d. 0.00000091

2) Write in standard form:

a. 5.2×10^3

b. 7.8×10^{-2}

c. 1.1×10^6

3) Which number is larger? 3.2×10^5 or 3.2×10^3 ? Explain how you know.

4) Explain why scientists use scientific notation.

6: Formulas & Equations

In math and science, you will often see letters mixed in with numbers. These letters are called variables. A variable is a symbol, usually a letter, that stands for a number.

$$2x = 14$$

Variables

The letter x is a variable. It stands for a number we do not know yet. Our job is to figure out what number makes the equation true.

Variables are useful because they allow us to write one rule that works for many different situations. Imagine trying to write a new math rule every time the numbers changed. Instead, we can use variables to create a general rule. For example:

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

D = density (g/mL or cm^3)

m = mass (g)

V = volume (mL)

Formulas

This formula can be used for the density of any substance, so we use variables to describe the relationship between the three terms.

An equation is any math sentence that contains an equal sign. A **formula** is a special kind of equation, that shows the relationship between different variables. Scientists use formulas because they can quickly solve problems by plugging in the values they know or have gathered from the lab.

In chemistry, you will use formulas all the time, but you will only be asked to solve for the one missing variable. So using the example above, you may know the density of a substance and its mass, so you would solve for its volume.

Solving

In order to solve for the single unknown variable in your formula, you need to **isolate the variable**. You do this by:

- Finding the unknown variable in the equation,
- Get it alone by doing the opposite operation
- Do the same thing to both sides to keep them equal to each other

$$\begin{array}{r} 2x = 14 \\ \hline 2 \quad 2 \\ \hline x = 7 \end{array}$$

You can see that x is being multiplied by 2. If you divide by 2 instead, you can get x alone. But make sure to divide 14 by 2 as well, so both sides remain equal!

Practice

1) Solve for x:

a) $3x+15 = 48$

b) $20-4x = 16$

c) $\frac{12x}{3} = 20$

d) $3x+4 = 19$

2) Rearrange the formula to solve for the missing variable:

a) $A=lw$ solve for w

b) $d=rt$ solve for t

c) $D=m/V$ solve for V

3) Why must you do the same operation to both sides of an equation?

7: Multiplying & Dividing Fractions

Fractions appear often in chemistry, but are rarely used for final answers. Most fraction answers must be converted to decimals. When you are presented with fractions, it's important to deal with them appropriately.

Multiplying Fractions

To multiply fractions, you treat it as two separate operations. The numerators (numbers on top) are multiplied, and the denominators (the numbers on the bottom) are multiplied, creating a new fraction as the answer.

If the answer should not be a fraction, then you divide to create a decimal for the answer.

$$\frac{2}{3} \times \frac{4}{5} = \frac{8}{15} \rightarrow 0.533$$

Dividing Fractions

In order to divide fractions, the first fraction should remain the same. Then second fraction will need to be flipped over (reciprocal). Then two fractions should be multiplied just like above.

$$\frac{7}{16} \div \frac{2}{3} = \frac{7}{16} \times \frac{3}{2} = \frac{21}{32} \rightarrow 0.656$$

Reducing Fractions

Reducing a fraction means rewriting it in its simplest form. A fraction is **simplified** when the numerator and denominator have no common factors other than 1.

To reduce a fraction, find the greatest common factor (GCF) of the numerator and denominator, then divide both by that number. Reducing fractions is important because it makes your answers easier to read and compare, and it is often required in math and science problems to show your final answer in simplest terms.

Both the numerator
and denominator
are divisible by 4.

$$\frac{8}{12} \rightarrow \frac{2}{3}$$

Practice

1) Multiply:

a) $\frac{1}{2} \times \frac{3}{4}$

b) $\frac{2}{5} \times \frac{10}{3}$

2) Divide:

a) $\frac{3}{4} \div \frac{1}{2}$

b) $\frac{5}{6} \div \frac{2}{3}$

3) Simplify:

a) $\frac{8}{16}$

b) $\frac{15}{20}$

3) Why is dividing by a fraction the same as multiplying by the reciprocal?

8: Setting Up Proportions

A proportion shows that two ratios are equal. In chemistry, proportions help you compare measurements. Typically, they are written as conversion factors.

Conversion Factors

A **conversion factor** is a fraction where the numerator and denominator are equal to each other, but are written in different units. Here are some examples:

$$\frac{4 \text{ quarters}}{1 \text{ dollar}}$$

$$\frac{1 \text{ year}}{365 \text{ days}}$$

$$\frac{12 \text{ donuts}}{1 \text{ dozen}}$$

Changing Units

Because conversion factors have a numerator and denominator that are equal to each other, they are effectively the same as multiplying by $1/1$, which simplifies to 1. We know that multiplying by one does not change the value being multiplied. Chemists often use this as a way to convert from one unit to another. You will learn more about this when you learn **dimensional analysis**, but for now, let's learn about setting up proportions.

Setting Up Proportions

Remember, the values you are using in your proportion must be equal to each other, and be represented as fractions. If you are working with a number that is not a fraction, you can divide it by 1. This would not change the value of the number at all, but will get it into the proper form.

When setting up a proportion, you need to ensure that your units align going across. For example, if a bakery charges \$1.25 per cookie, what would be the cost of 6 cookies?

$$\frac{\$ 1.25}{1 \text{ cookie}} = \frac{x \text{ dollars}}{6 \text{ cookies}}$$

Notice, the unit "dollars" is the numerator for each fraction, and "cookies" is the unit for each denominator. Ensure your units align horizontally!

When two fractions are set equal to each other, you don't multiply straight across like you learned in section 7. Instead, you cross multiply. We'll learn more about that in the next section.

Practice

1) Set up the proportion:

a) 4 apples cost \$8.25, what would 6 apples cost?

b) It takes 2.25 hours to read one chapter of a book. How long will it take to read the entire 13 chapters?

c) A car drives 14 miles per hour in traffic. At this rate, how long will it take to drive 8 miles?

d) A chemical with a mass of 102.6 grams has a volume of 38 cubic centimeters. What would be the volume of the sample if the mass were reduced in half?

e) Standard atmospheric pressure can be represented as 101.3 kPa or 1.0 atm. How many kPa is equivalent to 1.2 atm?

9: Cross Multiplying

Cross multiplying is how proportions are solved. It is different from multiplying fractions straight across.

When to Cross Multiply

When multiplying fractions, all of the numbers are known. There are no variables. In order to solve, you multiply the numerators, and then multiply the denominators to make a new fraction. Then you simplify that fraction if applicable.

Cross multiplying should happen when there are two fractions which are set equal to each other **AND there is an unknown variable in one of the fractions**. It does not matter if it is in a numerator or denominator.

How to Cross Multiply

Cross multiplying is how you solve for an unknown within a proportion. To solve for x, take the numerator of each fraction, and multiply it by the denominator of the other fraction. This will leave you with some number equal to some factor of x. Divide by that factor to get x by itself to find the value of x.

$$\frac{5}{6} = \frac{x}{4} \rightarrow 5 \times 4 = 6x \rightarrow 20 = 6x \rightarrow x = 3.33$$

Why This Works

Remember, both sides of the proportion are equal to each other. In reality, what we are doing is **multiplying both sides by both denominators**.

$$\frac{5}{6} = \frac{x}{4} \rightarrow (\cancel{6})(4) \frac{5}{\cancel{6}} = \frac{x}{\cancel{4}} (\cancel{6})(\cancel{4}) \rightarrow 5 \times 4 = 6x$$

On the left side, the 6 cancels with the 6 in the denominator. On the right, the 4 cancels with the 4 in the denominator of the second fraction. What we are left with is $5 \times 4 = 6x$. This leaves us with an equation that is much easier to solve. When we cross multiply, we don't actually write that we are multiplying out both denominators. **It's like we are multiplying and canceling in the same step.** That's part of why this is a shortcut!

Practice

1) Solve for each unknown:

a) 4 apples cost \$8.25, what would 6 apples cost?

b) It takes 2.25 hours to read one chapter of a book. How long will it take to read the entire 13 chapters?

c) A car drives 14 miles per hour in traffic. At this rate, how long will it take to drive 8 miles?

d) A chemical with a mass of 102.6 grams has a volume of 38 cubic centimeters. What would be the volume of the sample if the mass were reduced in half?

e) Standard atmospheric pressure can be represented as 101.3 kPa or 1.0 atm. How many kPa is equivalent to 1.2 atm?

10: Word Problems

Word problems can feel more difficult than regular math problems because they include sentences, extra information, and sometimes words you do not understand right away. However, most word problems are really just regular math problems hidden inside a story.

Finding Important Information

The most important step in solving a word problem is figuring out what information matters. Do not try to solve the problem as soon as you read it. Instead, read the problem carefully from beginning to end. As you read, circle or underline the important numbers. Then underline the units that go with those numbers. **The units help you to understand the story!**

What Are You Looking For?

Next, decide what the problem is asking you to find. Sometimes the question is at the very end. Look for words such as:

- how many
- how much
- what is
- find
- determine

Choose an Equation

Once you know what you are solving for, choose an equation or math skill that matches the problem. In high school level chemistry, **your equations should not have more than one unknown value**. A lot of the time, word problems include extra information that can either give you context to help you understand the situation, or be completely irrelevant. You will need to sharpen this skill throughout the year.

Estimation

After solving the problem, always check whether your answer makes sense. Ask yourself:

- Is the answer reasonable?
- Did I use the correct units?
- Did I answer the question that was asked?

If the answer does not make sense, go back and check your work. Many mistakes happen because students use the wrong numbers, forget the units, or choose the wrong operation. When in doubt go back to the calculator and punch in the numbers again, being mindful of the order of operations.

Practice

- 1) A student buys 3 notebooks for \$9. How much would 5 notebooks cost?

- 2) A recipe needs 2 cups of sugar for 12 cookies. How much sugar is needed for 30 cookies?

- 3) A car travels 180 miles in 3 hours. What is the speed?

- 4) A bottle contains 500 mL of water. You drink 125 mL. How much remains?

- 5) A classroom has 24 students. If 75% passed the test, how many students passed?

- 6) Why are units important in word problems?

11: Final Assessment

1) Evaluate: $12.01 + (1.008 \times 4)$

2) Convert 0.000036 to scientific notation

3) Convert 5.8×10^2 to scientific notation

4) Round 8.76 to the nearest tenth

Solve for x:

$$5) \frac{74.096 \text{ g}}{1 \text{ mol}} = \frac{x}{3.2 \text{ mol}}$$

$$6) \frac{128.04 \text{ g}}{2 \text{ mol}} = \frac{x \text{ g}}{4.8 \text{ mol}}$$

$$7) \frac{2 \text{ mol}}{56.04 \text{ g}} \times \frac{22.4 \text{ L}}{1 \text{ mole}}$$

8) A graph compares the amount of time spent on studying and test scores. What type of graph should be used to showcase the data?

9) Convert 35% to a decimal.

10) A lost dog travels 2 miles per day. How long will it take to travel 11 miles? Set up a proportion.

11) Solve the proportion you created in question 10.

12) Estimate $198 + 403$

13) A student investigates the volume of acid in a reaction and the speed at which the reaction occurs. Which metric would go on the x-axis of the graph showcasing the data?

14) What percent of a solution is vinegar if it is made with 100 mL of vinegar and 400 mL of water?

15) Solve for n and round your answer to the hundredths place:

$$(1.2 \text{ atm})(2.3 \text{ L}) = n(0.08206 \text{ Latm/molK})(273 \text{ K})$$