

Holy Cross High School
CPA Chemistry Summer Packet
2023-2024

I hope you are enjoying your summer! This packet is designed to help you prepare for chemistry this coming school year. Please write your answers on lined paper (you don't need to write the questions; just the answers, but make sure they are numbered clearly!). **For all math problems, you must show your work to get credit.** The completed packet will be due on the first day of class. **It will count as a quiz grade.** A 10% deduction will be assessed each day the packet is late. There will be a test on this material about two weeks into the school year.

It is expected that you work on the packet throughout the summer and not at the last minute. Tutorials are provided in the packet, but any information that you are unfamiliar with may be sought from other sources such as books, websites or YouTube videos.

Part 1: Units of Measurement

In chemistry we make a lot of measurements and do a lot of calculations with our measurements. **By definition, a measurement must have both a number and a unit.** You are probably already familiar with some units, such as miles, pounds, and seconds.

Please answer these questions:

1. Write down some of the units you already know for measuring **distance** (hint: a foot is one).
2. Write down some of the units you already know for measuring **time**.
3. Write down some of the units you already know for measuring **volume**.
4. Write some of the units you already know for measuring **mass**.
5. In science, do you think we should use the **British imperial system** of units, or the **metric system** of units? (If you don't know what these systems are, look them up.)

So as it turns out, in modern science we always use the metric system, because it is internationally accepted and much easier to work with than the English system. So

instead of measuring distance in feet, we will be using meters. Instead of measuring mass in pounds, we will be using grams.

Here is a list of common metric base units and what they are used to measure.

Unit	What it measures
grams	mass
meter	distance
liter	volume
second	time

In the metric system, there are **prefixes** for making the base units larger or smaller. The same prefixes can be applied to any base unit. The most important prefixes in chemistry are:

- ❖ kilo - 1,000 times bigger
- ❖ deci - 10 times smaller
- ❖ centi - 100 times smaller
- ❖ milli - 1,000 times smaller
- ❖ micro - 1,000,000 times smaller
- ❖ nano - 1,000,000,000 times smaller

For example:

100 centimeters = 1 meter

1000 meters = 1 kilometer

100 centigrams = 1 gram

1,000 millimeters = 1 meter

1,000,000 microliters = 1 liter

1,000,000,000 nanoliters = 1 liter

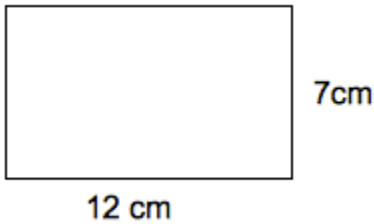
Please answer these questions:

6. How many nanometers are in a meter?
7. How many liters are in a kiloliter?
8. What unit do scientists use to measure **mass**?
9. What unit do scientists use to measure **volume**?

10. How many milligrams are in a kilogram?
11. What is mass? (look it up)
12. What is volume? (look it up)
13. CHALLENGE: How many millimeters are in a kilometer?

Part Two: Multiplying and Dividing Units

One thing about doing math with units is that the units behave similarly to variables in algebra. For example, suppose we are measuring the area of a rectangle:



The area would just be $(7\text{cm})(12\text{cm})$, giving us 84 cm^2 . Notice that the units multiply together, giving us squared centimeters.

We can also multiply two or more different units. For example, $12.4\text{ m} \times 6.2\text{ s} = 76.88\text{ m}\cdot\text{s}$

In addition, units can be divided. This happens when measuring speed. For example, if I travel 450 miles in 3 hours, my average speed is: $\frac{450\text{ miles}}{3\text{ h}} = 150\text{ miles/hour}$ (miles per hour).

Finally, units can cancel out if you have the same unit in the numerator and denominator. For example: $\frac{125\text{ s}\cdot\text{s}}{100\text{ s}} = 1.25\text{ s}$

Here are some more examples of math with units:

$$3 \text{ ft} \times 4 \text{ lb} = 12 \text{ ft} \cdot \text{lb}$$

$$\frac{5 \text{ miles}}{2 \text{ hr}} = 2.5 \frac{\text{miles}}{\text{hr}}$$

$$7 \frac{\text{miles}}{\text{hr}} \times 4 \text{ hr} = 28 \text{ miles}$$

$$3 \text{ ft} \times 4 \text{ ft} = 12 \text{ ft}^2$$

$$6 \text{ in.} \times 5 \frac{\text{in.}}{5} = 30 \frac{\text{in.}^2}{5}$$

$$\frac{6 \text{ grams}}{2 \text{ grams}} = 3 \text{ (3 is a } \textit{dimensionless} \text{ quantity)}$$

Please complete the following. Make sure to multiply and/or divide the units.

14. $\frac{(53 \text{ g})}{(4 \text{ L})} =$

15. $39 \text{ N} \times 9.4 \text{ m} =$

16. $(2 \text{ mL}) (0.5 \text{ mL}) (32 \text{ mL}) =$

17. $\frac{(4.08 \text{ g})}{(0.32 \text{ g})} =$

18. $\frac{1.57 \text{ L}}{2.0 \text{ L}} =$

19. $\frac{(35 \text{ m}) (2 \text{ m})}{25 \text{ s}} =$

20. $5.5 \text{ cm} \times 2 \text{ cm} \times 10 \text{ cm} =$

21. $\frac{35 \text{ miles}}{0.5 \text{ hours}} =$

22. $\frac{35 \text{ g}}{0.25 \text{ L}} =$

23. $(56 \text{ m})(2 \text{ m}) =$

Part Three: Conversion Problems

Doing conversions between units of measurement is an absolutely crucial skill for chemists.

You probably already know how to do simple conversions. For example: How many inches are in three feet? If you know that there are twelve inches in one foot, it is easy to see that two feet would be 24 inches, and three feet would be **36 inches**. But instead of counting feet, you could also multiply 12 inches by 3 to get the same answer.

What if I asked you how many inches are in a mile? Maybe you have no idea how to begin this problem; but what if I told you that there are 5,280 feet per mile? Now, you can figure out how many inches in a mile by multiplying 12 inches by 5,280 feet, which gives you **63,360 inches**.

In chemistry, converting between units to solve a problem is known as **dimensional analysis**. The main tool for dimensional analysis is called a **conversion factor**. A conversion factor is essentially a ratio of two measurements that are equal. For

instance, $\frac{12 \text{ inches}}{1 \text{ foot}}$ is a conversion factor. $\frac{5,280 \text{ feet}}{1 \text{ mile}}$ is another conversion factor.

Since the numerator and denominator of a conversion factor are equal, we can **invert** the conversion factor. So we could also write $\frac{1 \text{ foot}}{12 \text{ inches}}$ or $\frac{1 \text{ mile}}{5,280 \text{ feet}}$.

This probably seems unnecessary to you now, but I promise that it will be very useful in chemistry, as the conversions we will do are much more complicated than what you've done before. Most of the time, converting units involves just multiplication and/or division, but without conversion factors it's very easy to get confused about when to multiply and when to divide.

Let's try solving a more complex conversion problem using conversion factors.
How many inches are in 768.9 miles?

First, we should identify a few things.

What unit is the question asking for? **inches**

What unit is the question giving us? **miles**

What conversion factors can we use to solve this problem?

$$\frac{1 \text{ foot}}{12 \text{ inches}} \text{ and } \frac{1 \text{ mile}}{5,280 \text{ feet}}$$

So we take the number of miles and multiply it by **both** conversion factors to get our answer.

$$768.9 \text{ miles} \times \frac{5,280 \text{ feet}}{1 \text{ mile}} \times \frac{12 \text{ inches}}{1 \text{ foot}} = \mathbf{48,717,504 \text{ inches}}$$

Notice that we always set up the conversion factor so that all of the units cancel, except the unit we want for our answer. And notice that some conversions require multiple steps.

Please do the following metric conversions using conversion factors, making sure that one of the units cancels. Show your work.

24. Convert 4,500 g to kilograms.
25. Convert 2.3 L to milliliters.
26. Convert 1,450,000 centimeters to meters.
27. Convert 35 mm into cm.
28. Convert 9,674,430 grams into kilograms.
29. Convert 3.25 kilograms into milligrams.
30. Convert 6,700 millimeters into kilometers.
31. Convert 4,368 milligrams into kilograms.

Please do the following non-metric conversions as well. Use conversion factors and show your work.

32. How many dozen donuts are there in 244 doughnuts?
33. How many seconds are there in 1 year? (assume 365 days = 1 year)
34. How many dollars would 75 quarters be?
35. How many months are in 200,500 seconds?
36. How many inches are in 6 feet?
37. How many quarts are in 7 gallons? (1 gallon = 4 quarts)
38. How many pounds would 750 ounces be? (16 ounces = 1 pound)
39. Convert \$100 into dimes.

Part Four: Density

If we say that something is dense, we mean it has a lot of mass packed into a relatively small volume. **We can quantify density mathematically as simply mass divided by volume.** Since the units also divide, the units of density are usually some sort of grams over some sort of liters or cubic centimeters.

Examples:

- a) An object with a mass of 50g and a volume of 30 cm³ would have a density of

$$\frac{50g}{30cm^3} = 1.67 g/cm^3$$

- b) A sample of liquid has a volume of 34.2 mL and a mass of 52.3 g. Its density

would be $\frac{52.3g}{34.2mL} = 1.53g/mL$

- c) An object has a mass of 14.6 kg and a density of 4.83 g/mL. What is its volume?
We can use dimensional analysis to solve this problem, but first we need to convert

$$14.6 kg \times \frac{1,000 g}{1 kg} = 14,600 g$$

kilograms to grams. So, Then, we convert grams to milliliters, using the density as our conversion factor.

$$14,600g \times \frac{1 mL}{4.83 g} = 3,023 mL$$

Notice that we inverted the density so that grams were in the denominator, so that grams cancel.

Please complete the following:

40. Calculate the density of an object with a mass of 35.0 grams and a volume of 3.55 cm³.

41. Water has a density of 1.0 g/L. What volume of water has a mass of 250 g?

42. A block of aluminum occupies a volume of 0.015 L and has a mass of 40.5 g. What is its density?

43. Mercury metal is poured into a graduated cylinder that holds exactly 0.0225 liters. The mercury used to fill the cylinder weighs 306.0 g. From this information, calculate the density of mercury.

44. What is the mass of ethanol that exactly fills a 200.0 mL container? The density of ethanol is 0.789 g/mL.

45. A block of aluminum occupies a volume of 15.0 mL and weighs 40.5 g. What is its density?

Part 5: Percentages

Really, the word “percent” means “out of a hundred”, so any percent can be written as a fraction with a denominator of 100. For instance, $37\% = \frac{37}{100}$. Remember that when writing decimals, the second decimal place is called the “hundredths”. What this means is that the following are three ways to write the **same number**: $37\% = \frac{37}{100} = 0.37$

Here is another example: $52.9\% = \frac{52.9}{100} = 0.529$ **Notice that to convert a percent into a decimal, you simply move the decimal point two places to the left.**

Please fill in the table below. Each row should contain the same number written as a decimal, fraction, and percent.

Decimal	Percent	Fraction
0.12	12%	$\frac{12}{100}$
	43.6%	
		$\begin{array}{r} \square \square \square \\ \hline \square \square \square \end{array}$
	17.5%	
0.2536		

What if I asked you to take 22% of 450? Many calculators don't have a percent button. So the first thing you do is convert 22% into a decimal by moving the decimal point two places to the left, giving you 0.22. Then you just multiply 0.22 by 450, giving you 99.

One other thing about percents is we can convert any fraction into a percent by dividing the numerator by the denominator. For instance, $\frac{120}{10} = 1200\%$

Please Complete the following:

Round your final answers to the nearest hundredth.

46. A baseball pitcher won 75% of the games he pitched. If he pitched 43 ballgames, how many games did he win?

47. Tom, a plumber, worked 7.5 months of the year. What percent of the year did he work?

48. There are 28 students in a class. Fifteen of the students are female. What percent would be male?

49. Julie took her chemistry class and had 42 correct answers and 10 incorrect answers. What was the percentage of correct answers?

50. A student earned an 82% on a test that had 50 problems. How many problems did the student answer correctly?

51. A metal bar weighs 8.35 ounces. 73% of the bar is silver. How many ounces of silver are in the bar?

52. Joan purchased a car for 63% of the original price of \$35,000. How much did she pay for the car?

Part 6: Scientific Notation

Scientific notation is used often in chemistry to represent really small or really large numbers. **Scientific notation looks like this: $A \times 10^b$** where A is a number between one and ten, and b is an exponent.

How to convert from **scientific notation** to **standard form**:

The exponent on the ten tells us how many places to move the decimal. When the exponent on the ten is **positive**, we move the decimal to the **right**. When the exponent on the ten is **negative**, we move the decimal to the left.

Here are some **examples**:

$$2.7 \times 10^4 = 27,000$$

$$6.02 \times 10^{23} = 602,000,000,000,000,000,000,000$$

$$4.3 \times 10^{-4} = 0.00043$$

$$1.34 \times 10^{-6} = 0.00000134$$

How to convert from **standard form** to **scientific notation**:

Place the decimal after the first nonzero digit, and figure out how many spaces it would have to move to go back to standard form. The number of spaces becomes your exponent.

Examples:

$$0.0023 = 2.3 \times 10^{-3}$$

$$506,000 = 5.06 \times 10^5$$

$$0.000005683 = 5.683 \times 10^{-6}$$

$$1,230,400,000 = 1.2304 \times 10^9$$

Convert the following numbers into scientific notation:

53. 3,400 _____

54. 0.000023 _____

55. 101,000 _____

56. 0.010 _____

57. 45.01 _____

58. 1,000,000 _____

59. 0.00671 _____

60. 4.50 _____

Convert the following numbers into standard notation:

61. 2.30×10^4 _____

62. 1.76×10^{-3} _____

63. 1.901×10^{-7} _____

64. 8.65×10^{-1} _____

65. 9.11×10^3 _____

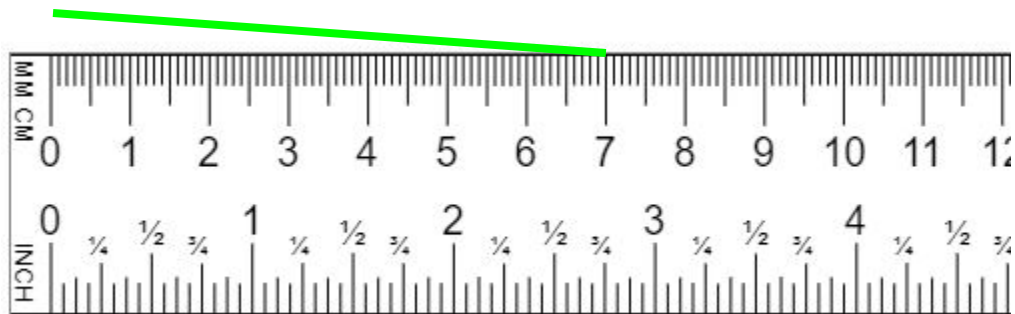
66. 5.40×10^1 _____

67. 1.76×10^0 _____

68. 7.4×10^{-5} _____

Part Seven: Significant Figures

Significant figures (or significant digits, or sig figs for short), are the digits that are reliable in science. You might be surprised to learn that not all digits are reliable! The distinction has to do with inherent limitations on measurements. Let's say you're measuring a distance with a meter stick that has marking for every millimeter, like this: 4



What is the length of the green bar? Some of you might say 7 cm, or 70 mm (which is the same thing). Others of you might say 6.9 cm (or 69 mm). In reality, the bar is somewhere in between 69 and 70 millimeters. We can estimate it at 69.5 mm, but the last digit is uncertain. **The significant figures of a measurement are all the digits that are known for sure, plus one that is estimated. So in our measurement above (69.5 mm), all three digits are significant.**

But what if we were measuring the diameter of a circle in order to find its circumference? In this case we would multiply the diameter (69.5 mm) times pi, giving us 218.3406.....and it goes on. So where do we round our answer to?

Since there were three significant figures in our original measurement, our calculation can only have three significant figures too. So we would round it to **218 mm**. **Usually, the number of significant figures in the original measurement is the number of significant figures in our answer.**

When reading a measurement, how do we know which digits are significant? There are a few rules.

Rule 1: Every nonzero digit is significant.

Rule 2: Zeros in between nonzero digits are significant.

Rule 3: “Leading zeros” are zeros to the left of nonzeros. They are NOT significant, because they are just placeholders.

Rule 4: “Trailing zeros” are zeros to the right of nonzeros. They are significant IF there is a decimal point anywhere in the number.

Rule 5: If there is no decimal point, trailing zeros are usually not considered significant.

Examples:

- 248 has 3 sig figs because they are all nonzeros
- 54008 has 5 sig figs because they are all nonzeros or “in-between” zeros
- 45.00 has 4 sig figs because the first two digits are nonzeros and there is a decimal point, making the trailing zeros significant.
- 0.00056 has only 2 sig figs, because leading zeros are never significant.

- e) 0.0340600 has 6 sig figs. Leading zeros are never significant, but since there is a decimal point, the trailing zeros are significant here.
- f) 54,000 has two sig figs, because trailing zeros are not significant if there is no decimal.

Please complete the following:

- 69) 31,000,000 has _____ significant figures
- 70) 102.3 has _____ significant figures
- 71) 40,000.0 has _____ significant figures
- 72) 500 has _____ significant figures
- 73) 104,000 has _____ significant figures
- 74) 5.000 has _____ significant figures
- 75) 231,509 has _____ significant figures
- 76) 980 has _____ significant figures
- 77) 807. has _____ significant figures
- 78) 222,000,200 has _____ significant figures