Dear Honors Chemistry,

I cannot wait to meet all of you this fall. Honors Chemistry is an incredible course where we learn to understand both the structure of matter and how matter transforms from one form to another.

However, before we can begin studying matter, we need to be able to understand how it is measured.Therefore, this summer, I am hoping that you will take the time to learn the metric system.

I expect you to memorize the metric prefixes below:

Prefix	Symbol	Meaning	Scientific Notation
Giga-	G	1,000,000,000	10^{9}
Mega-	M	1,000,000	10^{6}
Kilo-	k	1,000	10^{3}
Centi-	c	0.01	10^{-2}
Milli-	m	0.001	10^{-3}
Micro-	μ	0.000001	10^{-6}
Nano-	n	0.000000001	10^{-9}

I have attached a worksheet from the Internet that explains the **Factor Label Method** of converting units. I would strongly encourage you to use this method rather than simply moving the decimal, as the same strategy can be used to convert to English units, in addition to being very helpful for stoichiometry. At the end of the packet, there are practice problems with worked out solutions.

Regardless of what it says in the packet, the only conversion factors that you must memorize are the ones in the table above. However, you will need to be able to do every type of conversion covered in the packet. There will be a quiz on similar types of problems to these early in the school year.

On the page below, I have given you a set of practice problems without solutions. Please write out your work on a separate sheet of loose leaf paper, using the Factor Label Method. I will collect these for a grade on the **First Day of School.**

If you need help understanding dimensional analysis, feel free to email me at mhammond@eustace.org and I will be happy to help.

Sincerely,
Dr. Hammond

Summer Assignment Problems to be collected for grade. Please write the solutions on a separate sheet of loose leaf paper, showing all work using the Factor Label Method

1. How many meters are in 325 km?
2. How many liters are in 45.6 mL?
3. How many kilograms are 25 μg?
4. How many milliseconds are in 750 ns?
5. How many megabytes are in 42.3 GB?
6. How many milligrams are 35.3 kg?
7. How many micrometers are there in 24.5 cm?
8. How many centigrams are there in 0.034 kg?
9. How many pounds (lb) are there in 215 g
   (1 kg = 2.2 lb)
10. How many gallons are there in 2432 cm^3?
    (1 gallon = 4 quarts) (1.04 quarts = 1 L) (hint: 1 cm^3 = 1 mL)
11. Convert 4.56 g/mL into μg/μL
12. Find the mass of an 234 mL object that has the density of 3.23 g/mL
13. Convert 4.56 g/cm^3 into kg/m^3
    (hint you need to cube the conversion factor for length)
14. Find the volume in mL of a 45 g bar that has a density of 5.2 g/mL
15. How many meters are there in 12.5 cm?

Chapter 3 Metric Units and Conversions

3.1 The Metric System and Prefixes

Metric system: a simple decimal system of measurement that uses the following basic units:

Quantity	Basic Unit	Symbol
length	meter	m
mass	gram	g
volume	liter	L
time	second	s

Metric prefixes change the size of the basic unit to larger or smaller units. Each prefix represents a power of 10.

Know the following metric prefixes!

Prefix	Symbol	Multiplier
kilo	k	1000 times larger
deci	d	10 times smaller
centi	c	100 times smaller
milli	m	1000 times smaller
micro	μ	1,000,000 times smaller

3.2 Metric Conversions

In order to solve conversion problems you need to know how to set up the problem and how to write conversion factors. When two quantities are equal, you can write them in fraction form as a conversion factor. For example, 60 seconds equals 1 minute. Thus you can write the two conversion factors as $\left(\frac{60\ s}{1\ min}\right)$ or $\left(\frac{1\ min}{60\ s}\right)$. Which one you use depends on the given.

➢ Fill in the blanks to make the two quantities equal. **You must memorize these:**

1 m = _________ cm   1 m = _______________ μm

1 m = _________ dm   1 m = _______________ mm

1 km = _________ m   Note – meters could be grams or liters in these

To remember the number of centimeters or decimeters in a meter, just think of the number of cents or dimes in a dollar! Note metric conversion factors are all exact.

METRIC-METRIC CONVERSIONS

Factor Label Method: We will use this method for problem solving throughout the semester!

Factor Label Method Steps

1. Identify units for what you want to FIND (answer).
2. Identify the GIVEN (starting point).
3. Multiply GIVEN quantity by 1 or more conversion factors (shown as fractions) so that all units cancel except the units needed for the final answer. (Include units in your set-up!)
4. Check for correct units and round the final answer to the proper number of sig figs.

It should be noted that you never start with the conversion factor as you do not know yet which number should be on top! Always start with the GIVEN.

Example 1. How many meters is 4.5 km?

Given: 4.5 km Wanted: ? meters

Conversion Factors: 1000 m = 1 km

$4.5\text{ km}\left(\frac{1000\ m}{1\ km}\right) = 4500\text{ m}$

Example 2. How many µm are in 0.0257 cm?

Given: 0.0257 cm Wanted: ? µm

Conversion Factors: 100 cm = 1 m, 1,000,000 µm = 1 m

$0.0257\text{ cm}\left(\frac{1\ m}{100\ cm}\right)\left(\frac{1000{,}000\ um}{1m}\right) = 257\ \mu\text{m}$

When performing conversions, SHOW ALL WORK for full points in this class! If your set-up is correct, then all units cancel except for the final desired units.

⇒ Note that exact conversion factors and exact counted values do not limit sig figs. Use sig fig rules only for measured values (such as 15.8 g) or approximate conversion factors (454 grams = 1 pound is approximate)

3.3 English Conversions

English conversion factors we expect you to know: Note these are all exact.

2 cups = 1 pint	2 pints = 1 quart	4 quarts = 1 gallon
12 inches = 1 foot	3 feet = 1 yard	1760 yards = 1 mile
60 sec = 1 minute	60 min = 1 hour	24 hours = 1 day

Example 1: How many quarts are there if you have 8.25 cups?

Given: 8.25 cups Wanted: ? quarts

Conversion Factor: 2 cups = 1 pint, 2 pints = 1 quart

8.25 c $\left(\frac{1\ pint}{2\ cups}\right)\left(\frac{1\ quart}{2\ pints}\right)$ = 2.06 quarts

Example 2: How many feet is 39 inches?

Given: 39 inches Wanted: ? feet

Conversion Factor: 12 inches = 1 foot

39 inches $\left(\frac{1\ foot}{12\ inch}\right)$ = 3.3 feet

3.4 Metric - English Conversions

To go between the English and Metric systems you need the following conversion factors. These conversions will be given to you on quizzes and exams:

1 in. ≡ 2.54 cm (exact) 1 lb = 454 g (approximate) 1 qt = 946 mL (approximate)

These conversion factors linke the metric system to the English system for lengh, mass, and volume. Luckily, everyone uses the same units for time.

Example 1: How many mL are in 1.00 pint?

Given: 1.00 pint Wanted: ? mL

Conversion Factor: 2 pints = 1 quart, 1 quart = 946 mL

1.00 pint $\left(\frac{1\ quart}{2\ pints}\right)\left(\frac{946\ mL}{1\ quart}\right)$ = 473 mL

YouTube Conversion Problem 1

Example 2: How many meters are in a 100.0 yard football field?

Given: 100.0 yards Wanted: ? meters

Conversion Factors: 1 yard = 3 feet, 1 foot = 12 inch, 1 inch = 2.54 cm, 100 cm = 1 m

100.0 yds $\left(\frac{3\ ft}{1\ yd}\right)\left(\frac{12\ inch}{1\ ft}\right)\left(\frac{2.54\ cm}{1\ inch}\right)\left(\frac{1\ m}{100\ cm}\right)$ = 91.44 m

Note this answer shows us that yards and meters are NOT equal! 1 m does not equal 1 yard.

YouTube Conversion Problem 2

YouTube Conversion Problem 3

3.5 Volume by Displacement

The volume of an object can be measured by adding the object to a container holding water and finding the difference between the two water levels. If a volcanic rock is placed in a beaker containing 245.8 mL of water and the water level rises to 315.3 mL, what is the volume of the rock? The answer is found by subtraction. 315.3 mL – 245.8 mL = 69.5 mL.

Let's mention volume units - a mL is actually the exact same as a centimeter cubed or cm^3 which is often abbreviated as cc in the medical field. Thus mL = cm^3 = cc.

3.6 Volume by Calculation

Back in high school you probably learned how to calculate the volume of a rectangular solid, a sphere, and a cylinder. Do you recall those equations? Can you match the following equations to a rectangular solid, a sphere, and a cylinder?

1) $V = 4/3\ \pi\ r^3$ 2) $V = \pi\ r^2\ h$ 3) $V = l\ w\ h$

Well 1) is a sphere, 2) is a cylinder and 3) is a rectangular solid. We will expect you to remember V = l w h for a rectangular solid.

Example: Calculate the volume of a shoe box measuring 24 cm by 13 cm by 15 cm.

Answer: V = (24 cm)(13 cm)(15 cm) = 4700 cm^3

Did you say 4680 cm^3? Well remember sig fig rules. The answer must have no more significant digits than the problem which has only 2 sig figs. So we must round to 4700.

3.7 Density

Density: The amount of mass per unit volume of matter.

Density describes the relative compactness per area of a substance, which is based on the concentration of mass in a sample. The more atoms squeezed into a given area the denser the sample. If there is space between the atoms, the sample is not very dense. Density is not weight alone. Realize that 5 pounds of Styrofoam is heavier than 1 pound of steel, but the steel is still more dense than foam.

$density = \frac{\text{mass}}{\text{volume}}$ $\qquad$ $d = \frac{m}{V}$ $\qquad$ density units: $\frac{g}{cm^3}$ or $\frac{g}{mL}$ or $\frac{g}{cc}$

The density of gases is much, much lower than density of liquids and solids:

density (air) = 0.00129 $\frac{g}{cm^3}$; density (water) = 1.00 $\frac{g}{cm^3}$; density (gold) = 19.3 $\frac{g}{cm^3}$

There are two types of density calculations we will cover:

1. Calculating density given mass and volume. Simply divide.
2. Calculating mass or volume given density. Work as a conversion problem with density as the conversion factor. Remember, you never start a problem with the conversion factor so do not start the problem with the density!

Example 1: Calculate the density of ethanol if 40.0 mL masses 31.56 grams.

Answer: d = $\frac{31.56\ g}{40.0\ mL}$ = 0.789 g/mL

Example 2: Calculate the volume of gold needed to mass 79.3 grams if the density is 19.3 g/mL?

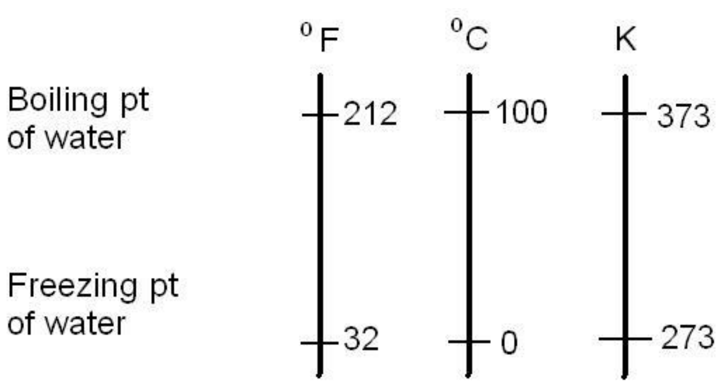
Answer: 79.3 g $\left(\frac{1\ mL}{19.3\ g}\right)$ = 4.11 mL

3.8 Temperature Conversions

Temperature: Measure of the average energy of a single particle in a system.

Hotness or coolness of a substance is determined by the average energy of the molecules in a system. Hot molecules move faster and have higher energy than cold molecules. Temperature is measured with a thermometer. There are 3 scales: English: Fahrenheit (°F); Metric: Celsius (°C) and Kelvin (K).

Boiling and Freezing point of water for the 3 temperature scales:



The Kelvin scale assigns a value of 0 K to the lowest possible temperature; this temperature is called absolute zero and corresponds to -273°C.

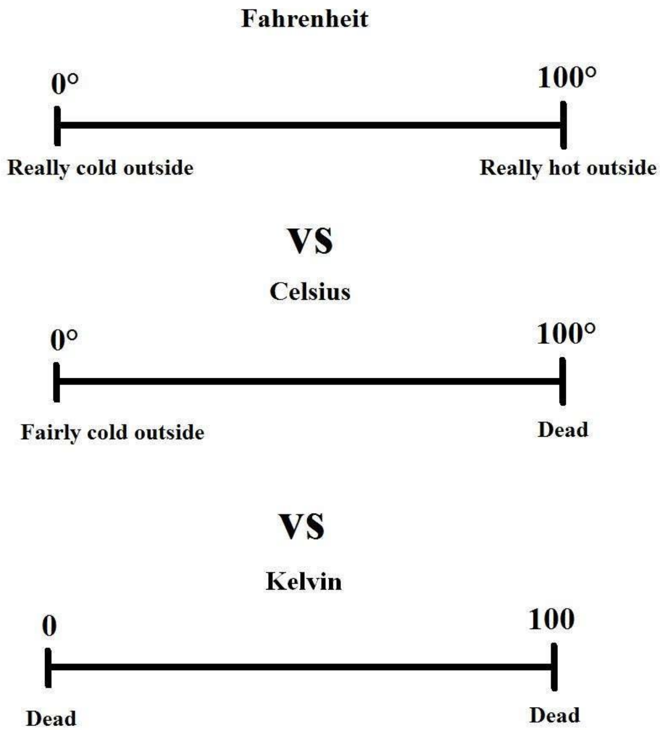
Conversions between Fahrenheit and Celsius scales:

$$°C = \frac{(°F - 32)}{1.8} \qquad °F = (°C \times 1.8) + 32$$

Conversion between °C and K: $K = °C + 273$

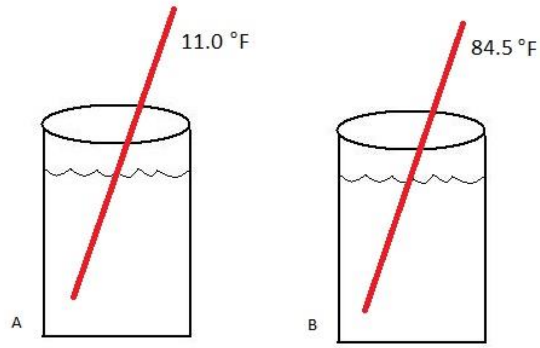
Example: Calculate Kelvin and Fahrenheit for a typical summer Tucson day of 39.8°C.

Answer: °F = (39.8 x 1.8) + 32 = 104°F and K = 39.8 + 273 = 313 K



3.9 Heat and Energy

Heat is a measure of the total energy of all the particles in a system.



1. Which of these two beakers, A or B, has the higher temperature? Why?
   Well B is at a higher temperature according to the thermometer. That was easy.

2. Which has the greater amount of heat? Why?
   Well A and B have the same volume, so B has more heat because the molecules or atoms are at a higher temperature moving faster thus more energy so there is more heat in that beaker.

Chemists often study heat in terms of heat transfer.

- ⇒ Heat transfers from a system at a higher temperature to one at a lower temperature
- ⇒ Thus, heat always transfers from hot to cold!

Example: Grandpa takes his famous cookies out of the oven. An anxious grandkid touches one then jerks his hand back because he got burned! What lost heat? What gained heat? Heat transferred from what to what?

Answer: The cookie lost heat. The hand gained heat. Heat transferred from the cookie to the kid's hand.

Practice Problems – try these on a separate sheet of paper

1. Convert 33.26 mL to L.
2. Convert 0.146 decigrams into milligrams
3. Convert 3.50×10^7 cm to km.
4. What is the mass in kilograms of a person weighing 175 pounds?
5. What is the volume in cups for a 2.0 L bottle?
6. Calculate the volume of a silver bar measuring 75 cm by 95 cm by 42 cm.
7. A diamond is placed in a graduated cylinder containing 35.0 mL of water. The volume of the water rises to 51.5 mL. What is the volume of the diamond?
8. Given the density of gold is 19.3 g/cm^3, write two unit factors.
9. Ethanol is used in alcoholic beverages and has a density of 0.789 g/mL. What volume of ethanol (in mL) would have a mass of 500.0 g?
10. Aluminum has a density of 2.70 g/cm^3. What is the mass of a piece of aluminum with a volume of 0.525 mL?

11. A piece of silver metal weighing 194 g is placed in a graduated cylinder containing 42.0 mL of water. The volume of water rises to 60.5 mL. Calculate the density of silver.
12. The book Fahrenheit 451 is based on 451˚F, the temperature at which paper ignites and burns. What is this temperature in degrees Celsius?
13. You win a trip to London in July. When you look up the average temperature, you find that it's expected to be about 28°C. What is the temperature in degrees Fahrenheit?
14. Room temperature is generally taken to be 25°C. What is the equivalent temperature in Kelvin?
15. In the movie Terminator 2, a tanker crashes and pours out liquid nitrogen. This freezes the T-1000 because liquid nitrogen has a temperature of 77 K. What is the equivalent temperature in degrees Celsius?
16. A small chunk of gold is heated in beaker #1, which contains boiling water. The gold chunk is then transferred to beaker #2, which contains room-temperature water.
    a. Does the temperature of the gold chunk increase, decrease, or stay the same? Explain your answer.
    b. Does the temperature of the water in beaker #2 increase, decrease, or stay the same? Explain your answer.
    c. What loses heat? What gains heat?
17. What happens when you hold an ice cube? What loses heat? What gains heat?
18. You just won 1460 quarters playing quarter slots. How many dollars is this?
19. You decide to take a trip to San Diego, which is about 355 miles from Glendale. If you average 65 mph with no stops, how many hours does it take to get there?
20. How many yards are there in a 26.2 mile marathon? (There are 5280 feet in one mile)

Answers to Practice Problems

1. $33.26 \text{ mL} \left(\frac{1 \text{ L}}{1000 \text{ mL}}\right) = 0.03326 \text{ L}$
2. $0.146 \text{ dg} \left(\frac{1 \text{ g}}{10 \text{ dg}}\right)\left(\frac{1000 \text{ mg}}{1 \text{ g}}\right) = 14.6 \text{ mg}$
3. $3.50 \times 10^7 \text{ cm} \left(\frac{1 \text{ m}}{100 \text{ cm}}\right)\left(\frac{1 \text{ km}}{1000 \text{ m}}\right) = 3.50 \times 10^2 \text{ km}$
4. $175 \text{ lbs} \left(\frac{454 \text{ g}}{1 \text{ lb}}\right)\left(\frac{1 \text{ kg}}{1000 \text{ g}}\right) = 79.5 \text{ kg}$
5. $2.0 \text{ L} \left(\frac{1000 \text{ mL}}{1 \text{ L}}\right)\left(\frac{1 \text{ quart}}{946 \text{ mL}}\right)\left(\frac{2 \text{ pints}}{1 \text{ quart}}\right)\left(\frac{2 \text{ cups}}{1 \text{ pint}}\right) = 8.5 \text{ cups}$
6. V = (75 cm) (95 cm) (42 cm) = $3.0 \times 10^5 \text{ cm}^3$ (you must put in sci notation to display 2 sig figs)
7. V = 51.5 mL – 35.0 mL = 16.5 mL
8. $\frac{19.3\,g}{1\,cm^3}$ and $\frac{1\,cm^3}{19.3\,g}$
9. $500.0 \text{ g} \left(\frac{1 \text{ mL}}{0.789 \text{ g}}\right) = 634 \text{ mL}$
10. $0.525 \text{ mL} \left(\frac{2.70 \text{ g}}{1 \text{ mL}}\right) = 1.42 \text{ g}$

11. 60.5 mL – 42.0 mL = 18.5 mL $\qquad d = \frac{m}{v} \qquad d = \frac{194\ g}{18.5\ mL} =$ 10.5 g/mL

12. °C = $\frac{451-32}{1.8} = \frac{419}{1.8}$ = 233 °C

13. °F = (1.8 x 28) + 32 = 82 °F

14. K = 25 + 273 = 298 K

15. °C = 77 -273 = -196 °C

16. A. gold chuck decreases as it cools off in the room temp water. B. water increases cause the hot metal chunk warms it up C. gold loses heat, water gains heat, heat transfers from gold to water

17. When you hold ice, you melt the ice with the heat of your hand. The ice gains heat from your hand, your hand loses heat to the ice, heat transfers from hand to ice.

18. 1460 quarters $\left(\frac{1\,dollar}{4\,quarters}\right)$ = **$365**

19. 355 miles$\left(\frac{1\,hr}{65\,miles}\right)$ = 5.5 hours

20. 26.2 miles $\left(\frac{5280\ ft}{1\,mile}\right)\left(\frac{1\,yd}{3\ ft}\right)$ = **4.61 x 10^4 yd**