Chemistry
Unit 7

Moles

You will need a calculator and a periodic table

The **molecular mass** or **molar mass** is the total mass of a compound. It is equal to the **sum of the individual atomic masses** of each atom in the molecule. The units for molar mass calculations are always grams per mole (g/mol).

It is easy to find the molecular mass of a compound with these steps.

1. Determine the chemical formula of the compound.
   For example: The formula for glucose is $C_6H_{12}O_6$
   The formula for Nickel (II) nitrate is $Ni(NO_3)_2$

2. Use the periodic table to determine the atomic mass of each element in the molecule.

   From the examples above, glucose has 3 elements (C, H, O) and nickel (II) nitrate also has 3 elements (Ni, N, O)
   Round the atomic mass on the periodic table to **two decimal places**

Glucose: $C_6H_{12}O_6$		Nickel (II) nitrate: $Ni(NO_3)_2$	
C-	12.01	Ni-	58.69
H-	1.01	N-	14.01
O-	16.00	O	16.00

3. Multiply each element's atomic mass by the number of atoms of that element in the molecule. This number is represented by the subscript next to the element symbol in the chemical formula.

4.

Glucose: $C_6H_{12}O_6$		Nickel (II) nitrate: $Ni(NO_3)_2$	
C-	12.01 x **6** = 72.06	Ni-	58.69 x **1** = 58.69
H-	1.01 x **12** = 12.12	N-	14.01 x **2** = 28.02
O-	16.00 x **6** =96.00	O	16.00 x **6** = 96.00

5. Add these values together in order to find the total molar mass of the compound.

   Molar mass for Glucose ($C_6H_{12}O_6$) = 72.06 + 12.12 + 96.00 = 180.18 g/mol

   Molar mass for Nickel (II) nitrate: $Ni(NO_3)_2$ = 58.69 + 28.02 + 96.00 = 182.71 g/mol

Using these guided steps, complete page 1 in Unit Book 7. Hint: It might be easier to start with 7-12.

Molar Mass Worksheet

Part 1: Write the formula for the following compounds, then calculate the molar mass.

1. Iron (III) chloride

2. Magnesium hydroxide

3. Phosphoric acid

4. Lead (II) nitrate

5. Gallium (III) sulfate

6. Ammonium sulfate

Part II: Calculate the molar mass of the following compounds

7. NaBr

8. $C_6H_{12}O_6$

9. $Zn(C_2H_3O_2)_2$

10. $(NH_4)_2CO_3$

11. CCl_2F_2

12. CH_3COOH

Name _____ #_____
Date _____ Hour _____ Chemistry

% Comp WS

Percent Composition Worksheet

Determine the % composition of all elements in these compounds. Show all work!

1) **ammonium sulfite**
Formula _____
Molar mass _____
Mass of N _____ % N _____
Mass of H _____ % H _____
Mass of S _____ % S _____
Mass of O _____ % O _____

2) **aluminum acetate**
Formula _____
Molar mass _____
Mass of Al _____ % Al _____
Mass of C _____ % C _____
Mass of H _____ % H _____
Mass of O _____ % O _____

3) **sodium bromide**
Formula _____
Molar mass _____
Mass of Na _____ % Na _____
Mass of Br _____ % Br _____

4) **copper (II) hydroxide**
Formula _____
Molar mass _____
Mass of Cu _____ % Cu _____
Mass of O _____ % O _____
Mass of H _____ % H _____

5) **magnesium carbonate**
Formula _____
Molar mass _____
Mass of Mg _____ % Mg _____
Mass of C _____ % C _____
Mass of O _____ % O _____

Mole Conversions Worksheet

There are three mole equalities. They are:

1 mol = 6.02×10^{23} particles
1 mol = molar mass (periodic table)
1 mol = 22.4 L for a gas at STP

Mole-atom Conversions

1. How many moles of magnesium is 3.01×10^{22} atoms of magnesium?

2. How many molecules are there in 4.00 moles of glucose, $C_6H_{12}O_6$?

3. How many moles are 1.20×10^{25} atoms of phosphorous?

4. How many atoms are in 0.750 moles of zinc?

5. How many molecules are in 0.400 moles of N_2O_5?

Mole-Mass Conversions

1. How many moles in 28 grams of CO_2 ?

2. What is the mass of 5 moles of Fe_2O_3 ?

3. Find the number of moles of argon in 452 g of argon.

4. Find the grams in 1.26×10^{-4} mol of $HC_2H_3O_2$.

5. Find the mass in 2.6 mol of lithium bromide.

Mole-Volume Conversions

1. Determine the volume, in liters, occupied by 0.030 moles of a gas at STP.

2. How many moles of argon atoms are present in 11.2 L of argon gas at STP?

3. What is the volume of 0.05 mol of neon gas at STP?

4. What is the volume of 1.2 moles of water vapor at STP?

Mixed Mole Conversions

Given unit → Moles → Desired unit

1. How many oxygen molecules are in 3.36 L of oxygen gas at STP?

2. Find the mass in grams of 2.00×10^{23} molecules of F_2.

3. Determine the volume in liters occupied by 14 g of nitrogen gas at STP.

4. Find the mass, in grams, of 1.00×10^{23} molecules of N_2.

5. How many particles are there in 1.43 g of a molecular compound with a molar mass of 233 g?

6. Aspartame is an artificial sweetener that is 160 times sweeter than sucrose (table sugar) when dissolved in water. It is marketed by G.D. Searle as *Nutra Sweet*. The molecular formula of aspartame is $C_{14}H_{18}N_2O_5$.

a) Calculate the gram-formula-mass of aspartame.

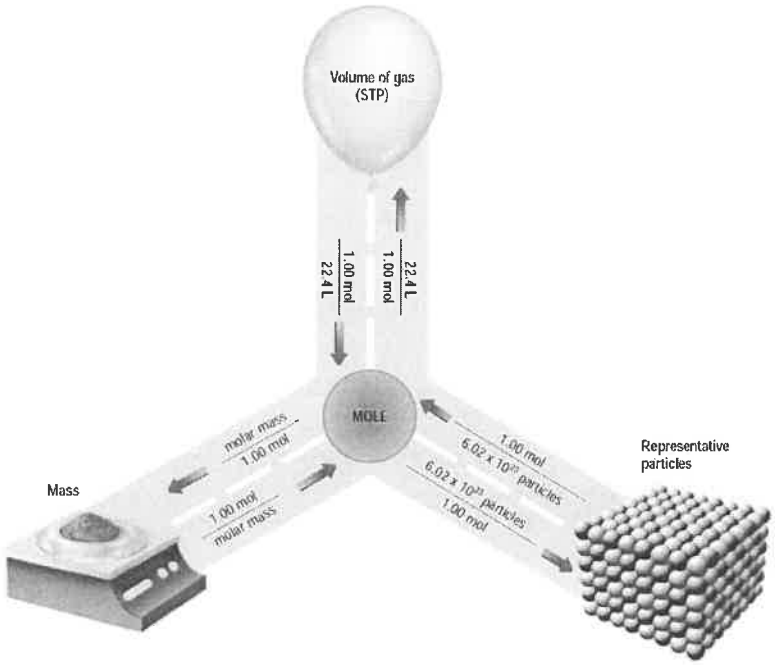
b) How many moles of molecules are in 10 g of aspartame?

c) What is the mass in grams of 1.56 moles of aspartame?

d) How many molecules are in 5 **mg** of aspartame?

e) How many atoms of nitrogen are in 1.2 grams of aspartame?

Name: _____ **Hour:** _____ **Date:**_____



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Conversion Factors:
(these factors describe what one mole of a substance can be equal to, these form the "bridges" of our dimensional analysis).

1 mole = 6.02×10^{23} atoms

1 mole = element's atomic mass in grams (calculated the same way formula mass is calculated)

1 mole = 22.4 liters of ANY gas at STP*
*STP = standard temperature and pressure

Particle Conversion: Changing between units of Moles and Atoms

1. How many Mg atoms are in 3.24 moles of Mg?

2. 2.68×10^{24} atoms of Cu equal how many moles?

3. How many moles are 1.505×10^{23} Na atoms?

Mass Conversions: Converting between Grams and Moles

4. Convert 5.00 moles of carbon to grams.

5. Convert 4.86×10^{4}g of Mg to moles.

6. Convert 9.213 moles of Fe to grams.

Volume Conversions: Converting between Volume and Moles

7. What volume will 5 moles of O_2 gas occupy at STP?

8. A container holds 7.5 liters of CO_2 at STP, how many moles of gas is this?

9. H_2 gas at STP occupies 57L of space, how many moles of H_2 are present?

Mixed Mole Problems (some may require more than one step)

10. Convert 84,520 mg of Ne to atoms.

11. How many atoms are in 45.6 grams of sulfur?

12. How many moles are in 68 grams of copper (II) hydroxide, $Cu(OH)_2$?

13. What is the mass of 8.944×10^{18} iron atoms in mg?

14. How many grams are in 3.3 moles of potassium sulfide, K_2S?

15. How many grams does 60 liters of oxygen gas weigh?

Putting it Together Problems

16. What is the density of helium? (What is the mass of one mole; what is the volume of one mole?, density = Mass/Volume)

17. What is the density of Carbon di-oxide(CO_2) gas?

Mole conversion classwork Name: _____

Instructions: Show your work for all of the following problems. You may use your notes and a calculator, but not your cell phone. The assignment is due at the end of class. Any problems you do not finish will be counted incorrect. Answers must include the correct number of significant figures and units for full credit. Please put a **BOX** around your final answer.

1. What is the molar mass AND percent composition of glucose ($C_6H_{12}O_6$)

2. What is the molar mass and percent composition for calcium phosphate? (Hint, you'll need the chemical formula 1st.)

3. Draw MOLE ISLAND in the space provided below:

4. How many moles are in 15 grams of lithium?

5. How many liters does 2.3 grams of oxygen gas occupy at STP?

6. Find the mass in grams of 2.00×10^{23} molecules of F_2.

7. Convert 9.213 moles of Fe to grams of Fe.

8. Convert 84,520 mg of potassium chloride to atoms of potassium chloride.

9. How many grams does 60.5 liters of nitrogen gas weigh?

10. How many moles of xenon atoms are in 15.3 L of xenon gas at STP?

11. What is the mass of 2.50 mol of iron (III) oxide?

12. A substance has a molar mass of 215 g/mol. If you obtain 4.00 grams of the substance, how many atoms do you have?

13. Calculate the number of grams in 1.4×10^{24} molecules of HCl.

14. How many molecules of sulfur dioxide are present in 1.60 moles of sulfur dioxide?

15. Determine the volume, in milliliters, of 0.050 moles of a gas at STP.

16. How many molecules are in 1.50 moles of water?

17. How much space will 27.6 grams of oxygen gas occupy at STP?

18. How many grams are in 4.50 moles of sodium chloride?

Simple vs. True
Calculating Empirical and Molecular Formulas

How do chemists determine the true chemical formula for a newly synthesized or unknown compound? In this lesson we will explore some of the mathematics chemists apply to experimental evidence to quickly and accurately determine the true chemical formula of a compound.

PURPOSE
In this lesson you will learn problem-solving strategies that will enable you to calculate empirical and molecular formulas given experimental data.

MATERIALS
calculator
periodic table
student white boards (optional)

CLASS NOTES
The simplest formula or *empirical formula* for a compound represents the smallest whole number ratio of atoms present in a given chemical substance. The *molecular formula* represents the true ratio of atoms actually present in a molecular compound. Sometimes the empirical formula and the molecular formula are identical. For example, the formula for water, H_2O, is both the simplest ratio of atoms contained per molecule of water as well as the true ratio. In other instances, the molecular formula is a whole number multiple of the empirical formula. For example, the formula for butane is C_4H_{10}. This formula represents the molecular formula, which is the true ratio of atoms present in a molecule of butane. The empirical formula for this compound is easily determined by reducing the subscripts to the simplest whole number ratio possible. This is accomplished by dividing all of the subscripts by the greatest common factor, which is 2, to yield C_2H_5. For ionically-bonded substances, the empirical formula is the representation of the smallest formula unit. For example, in the formula NaCl, Na and Cl are in a 1:1 ratio, however, sodium chloride crystals are actually arranged in a crystal lattice that is face-centered cubic. One unit cell requires many more ions yet maintains the 1:1 ion to ion ratio.

When a new substance is discovered, the formula is unknown until some qualitative and quantitative analyses are performed on the compound. First, qualitative analysis reveals which elements are in the compound. Next, quantitative analysis determines the amounts of those elements in the compound. Chemists use this type of experimental data to determine the empirical formula. Additional data must be collected in order to determine the molecular formula.

17 *Simple vs. True*

CALCULATING EMPIRICAL FORMULAS

1. Convert the grams given for each element into moles. If the data is given as percent composition data, it is simplest to assume a 100g sample so that each percentage is converted directly to grams. For example, if a compound contains 20.0% Na, then convert this directly to 20.0 grams of sodium and then convert the quantity into moles of sodium. Record the number of moles to at least four significant figures. Rounding early is not recommended.

2. Examine your mole calculations and identify the least number of moles calculated. Divide all of the mole calculations by the smallest number of moles calculated to simplify the mole:mole ratio. This step may yield whole numbers or very close to whole numbers. If so, these whole numbers serve as the subscripts for the empirical formula.
   a. If the mole:mole ratio contains numbers other than whole numbers you may have to multiply *all* of the moles by the same factor to convert them to whole numbers. Try multiplying by 2 first, then by 3, etc.

   b. For example: If the mole:mole ratio comes out 1: 2.5: 1; multiplying each number in the ratio by 2 will yield the same proportion, but eliminate the ½. The ratio becomes 2: 5: 2. Remember that subscripts must be whole numbers so your calculated mole:mole ratio must be very near whole numbers. Also, remember you must multiply *all* of the calculated moles by the *same* number to keep them proportional.

   c. Watch for numbers that have the following terminal decimal values:
      - ≈0.20 (multiply by 5 to yield ≈1.0)
      - ≈0.25 (multiply by 4 to yield ≈1.0)
      - ≈0.33 (multiply by 3 to yield ≈1.0)
      - ≈0.50 (multiply by 2 to yield ≈1.0)
      - ≈0.67 (multiply by 3 to yield ≈ 2.0)
      - ≈0.75 (multiply by 4 to yield ≈ 3.0)
      - ≈0.80 (multiply by 5 to yield ≈ 4.0)

3. Write the empirical or molecular formula with proper subscripts and name the compound if asked. (Usually the problem lists the elements in the order they appear in the formula.)

EXAMPLE PROBLEM 1:

Many of the biochemicals in our body consist of the elements carbon, hydrogen, oxygen and nitrogen. One of these chemicals, norepinephrine, is often released during stressful times and serves to increase our metabolic rate during the "fight or flight" response. The percent composition of this hormone is 56.8% C, 6.56% H, 28.4% O, and 8.28% N. Calculate the simplest formula for this biological compound.

EXAMPLE PROBLEM 2:
A sample of a white, granular ionic compound having a mass of 41.764 grams was found in the photography lab. Analysis of this compound revealed that it was composed of 12.144 grams of sodium, 16.948 grams of sulfur, and the rest of the compound was oxygen. Calculate the empirical formula for this compound and provide its name.

CALCULATING MOLECULAR FORMULAS
It may be necessary for you to calculate the empirical formula first in order to determine the molecular formula. The molecular formula is simply a multiple of the empirical formula.

1. Calculate the empirical formula mass.

2. Determine the factor that the empirical formula will be multiplied by to determine the molecular formula. Simply divide the molecular mass by the empirical formula mass. This should yield a whole number.

3. Multiply all of the subscripts in the empirical formula by the whole number obtained from the previous step to get the true ratio of atoms in the molecular formula.

EXAMPLE PROBLEM 3:

Calculate the molecular formula for an organic compound whose molecular mass is 180. $\frac{g}{mol}$ and has an empirical formula of CH_2O. Name this compound.

EXAMPLE PROBLEM 4:
An organic alcohol was quantitatively found to contain the following elements in the given proportions: C = 64.81%; H = 13.60%; O = 21.59%. Given that the molecular weight of this alcohol is 74 g/mol, determine the molecular formula and name this alcohol.

EXAMPLE PROBLEM 5:
A 71.5 mg sample of an unknown petroleum product was quantitatively analyzed. It was determined that the compound contained 60.1 mg carbon and 11.4 mg hydrogen. Through mass spectrometry, the molecular mass was found to be 114.26 g/mol. What is the molecular formula? Name this molecular compound.

Name _____

Period _____

Simple vs. True
Calculating Empirical and Molecular Formulas

ANALYSIS

Solve the following problems on this answer page. Be sure to show all work for full credit.

1. A 2.676 gram sample of an unknown compound was found to contain 0.730 g of sodium, 0.442 g of nitrogen and 1.504 g of oxygen. Calculate the empirical formula for this compound and name it.

2. A mysterious white powder was found at a crime scene. It was quantitatively analyzed and its percent composition was determined to be 27.37% sodium, 1.20% hydrogen, 14.30% carbon with the remainder being oxygen. Calculate the empirical formula for this compound.

3. A common organic solvent has an empirical formula of CH and a molecular mass of 78 g/mole. Calculate the molecular formula for this compound.

4. A gas was qualitatively analyzed and found to contain only the elements nitrogen and oxygen. The compound was further analyzed to it was determined the gas was composed of 30.43% nitrogen. Given that the molecular mass of the compound is 92.0 g/mole, calculate the molecular formula.

Empirical and Molecular Formulas Worksheet

Objectives:

- be able to calculate empirical and molecular formulas

Empirical Formula

1) What is the empirical formula of a compound that contains 0.783g of Carbon, 0.196g of Hydrogen and 0.521g of Oxygen?

2) What is empirical formula of a compound which consists of 89.14% Au and 10.80% of O?

3) What is empirical formula if compound consists of 21.2%N, 6.1%H, 24.2%S and 48.5%O?

Molecular Formula

4) Empirical formula of a substance is CH_2O. Molar mass is 180. What is the molecular formula?

5) Sample (3.585g) contains 1.388g of C, 0.345g of H, 1.850g O and its molar mass is 62g. What is molecular formula of this substance?

Empirical and Molecular Formula Worksheet

1. An oxide of chromium is found to have the following % composition: 68.4 % Cr and 31.6 % O. Determine this compound's empirical formula.

2. The percent composition of a compound was found to be 63.5 % silver, 8.2 % nitrogen, and 28.3 % oxygen. Determine the compound's empirical formula.

3. A 170.00 g sample of an unidentified compound contains 29.84 g sodium, 67.49 g chromium, and 72.67 g oxygen. What is the compound's empirical formula?

4. A 60.00 g sample of tetraethyl lead, a gasoline additive, is found to contain 38.43 g lead, 17.83 g carbon, and 3.74 g hydrogen. Find its empirical formula.

5. A compound containing 5.9265 % H and 94.0735 % O has a molar mass of 34.01468 g/mol. Determine the empirical and molecular formula of this compound.

6. The empirical formula for trichloroisocyanuric acid, the active ingredient in many household bleaches, is OCNCl. The molar mass of this compound is 232.41 g/mol. What is the molecular formula of trichloroisocyanuric acid?

7. Determine the molecular formula of a compound with an empirical formula of NH_2 and a formula mass of 32.06 amu.

8. The empirical formula of a hydrocarbon (compound that contains only C and H) is found to be CH. Laboratory procedures have found that the molar mass of the compound is 78 g/mol. What is the molecular formula of this compound?

9. The molar mass of nicotine is 162.1 g/mol. It contains 74.0 % carbon, 8.7 % hydrogen, and 17.3 % nitrogen. Determine nicotine's empirical formula and molecular formula.

10. Phenyl magnesium bromide is used as a Grignard reagent in organic synthesis. Determine its empirical and molecular formula if its molar mass is 181.313 g/mol and it contains 39.7458 % C, 2.77956 % H, 13.4050 % Mg, and 44.0697 % Br.

Name: _____.

Review: Moles, Molecules, Empirical/Molecular Formula

Mole conversions

Make the following conversion. Remember, formula mass = g/mol; 6.02 X 10^{23} atoms or molecules = 1 mole

1. Determine the number of moles of 25.75 grams of H_2O.

2. Determine the number of moles of 5.76 grams of sulfuric acid.

3. Determine the number of moles of 75.0 grams of barium chloride.

4. Determine the number of grams found in 0.456 moles of carbon dioxide.

5. Determine the weight in 227.25 L of hydrogen gas.

6. Determine the number of molecules of 45.0 grams of water.

7. Determine the number of grams in 5.5 X 10^{23} atoms of gold.

8. Determine the number of grams found in 12.04 X 10^{23} molecules of sodium chloride.

Empirical/Molecular Formulas

9. Determine the % composition for each element in a molecule of aspartame, $C_{14}H_{18}N_2O_5$.

10. What is the empirical formula of a molecule containing 18.7% lithium, 16.3% carbon, and 65.0% oxygen?

11. The analgesic, aspirin, has the following elemental percent composition: 60.00% C, 4.48% H, and 35.53% O.
    a. Find the empirical formula of aspirin.

    b. If the molar mass of aspirin is 180 g/mol, what is the molecular formula of aspirin?

12. Determine the empirical formula of a compound that contains 2.0g of hydrogen, 32.7g of sulfur, and 65.2g of oxygen.

13. Lindane is an insecticide used to kill lice. The elemental percent composition of lindane is: 24.78% C, 2.08% H, and 73.14% Cl.
    a. Find the empirical formula of lindane.

    b. If the molar mass of lindane is 290 g/mol, what is the molecular formula of lindane?

14. Determine the empirical formula of a compound that contains 77.4g of potassium (K), 27.6g of nitrogen, and 95.0g of oxygen.

15. Many sunscreens contain the compound para-aminobenzoic acid (PABA). The elemental percent composition of PABA is: 61.31% C, 5.15% H, 10.21% N, and 23.33% O.
    a. Find the empirical formula of PABA.

    b. If the molar mass of PABA is 137 g/mol, what is the molecular formula of PABA?

16. Find the volume of each of the following amounts of gas at STP—
    a. 0.72 moles O_2
    b. 3.4 moles N_2
    c. 57 g CO_2
    d. 320 g Rn

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EXTRA MATH REVIEW

Examples:

3.57 mL has 3 significant digits (Rule 1)
288 mL has 3 significant digits (Rule 1)
20.8 mL has 3 significant digits (Rule 1 and 2a)
20.80 mL has 4 significant digits (Rules 1, 2a and 2b)
0.01 mL has only 1 significant digit (Rule 1)
0.010 mL has 2 significant digits (Rule 1 and 2b)
0.0100 mL has 3 significant digits (Rule 1 and 2b)
3.20×10^4 kg has 3 significant digits (Rule 1 and 2b)

SIGNIFICANT DIGITS IN CALCULATIONS

A calculated number can never contain more significant digits than the measurements used to calculate it.

Calculation rules fall into two categories:

1. Addition and Subtraction: answers must be rounded to match the measurement with the *least* number of *decimal places*.
   37.24 mL + 10.3 mL = 47.54 (calculator value), report as 47.5 mL

2. Multiplication and Division: answers must be rounded to match the measurement with the *least* number of *significant digits*.
   1.23 cm × 12.34 cm = 15.1782 (calculator value), report as 15.2 cm^2

DIMENSIONAL ANALYSIS

Throughout your study of science it is important that a unit accompanies all measurements. Keeping track of the units in a problem can help you convert one measured quantity into its equivalent quantity of a different unit or set up a calculation without the need for a formula.

In conversion problems, equality statements such as 1 ft = 12 inches, are made into fractions and then strung together in such a way that all units except the desired one are canceled out of the problem. Remember that defined numbers, such as the 1 and 12 above, are exact numbers and thus will not affect the number of significant digits in your answer. This method is also known as the Factor-Label method or the Unit-Label method.

To set up a conversion problem follow these steps.

1. Think about and write down all the "=" statements you know that will help you get from your current unit to the new unit.

2. Make fractions out of your "=" statements (there could be 2 fractions for each "="). They will be reciprocals of each other.

3. Begin solving the problem by writing the given amount with units on the left side of your paper and then choose the fractions that will let a numerator unit be canceled with a denominator unit and vice versa.

4. Using your calculator, read from left to right and enter the numerator and denominator numbers in order. Precede each numerator number with a multiplication sign and each denominator number with a division sign. Alternatively, you could enter all of the numerators, separated by multiplication signs, and then all of the denominators, each separated by a division sign.

5. Round your calculator's answer to the same number of significant digits that your original number had.

Example: How many inches are in 1.25 miles?

Solution:

$1\text{ ft} = 12\text{ in.}$ $\quad \dfrac{1\text{ ft}}{12\text{ in.}}$ OR $\dfrac{12\text{ in.}}{1\text{ ft}}$

$5280\text{ ft} = 1\text{ mile}$ $\quad \dfrac{5280\text{ ft}}{1\text{ mile}}$ OR $\dfrac{1\text{ mile}}{5280\text{ ft}}$

$$1.25\text{ miles} \times \frac{5280\text{ ft}}{1\text{ mile}} \times \frac{12\text{ in.}}{1\text{ ft}} = 79{,}200\text{ in.}$$

As problems get more complex the measurements may contain fractional units or exponential units. To handle these problems treat each unit independently. Structure your conversion factors to ensure that all the given units cancel out with a numerator or denominator as appropriate and that your answer ends with the appropriate unit. Sometimes information given in the problem is an equality that will be used as a conversion factor.

Example: Suppose your automobile tank holds 23 gal. and the price of gasoline is 33.5¢ per L. How many dollars will it cost you to fill your tank?

Solution: From a reference table we will find,

1 L = 1.06 qt
4 qt = 1 gal.

We should recognize from the problem that the price is also an equality, 33.5¢ = 1 L
and we should know that 100¢ = 1 dollar

Setting up the factors we find,

$$23\text{ gal.} \times \frac{4\text{ qt}}{1\text{ gal.}} \times \frac{1\text{ L}}{1.06\text{ qt}} \times \frac{33.5¢}{1\text{ L}} \times \frac{\$1}{100¢} = \$29$$

In your calculator you should enter $23 \times 4 \div 1.06 \times 33.5 \div 100$ and get 29.0754717. However, since the given value of 23 gal. has only 2 significant digits, your answer must be rounded to \$29.

Squared and cubed units are potentially tricky. Remember that a cm^2 is really cm × cm. So, if we need to convert cm^2 to mm^2 we need to use the conversion factor 1 cm = 10 mm *twice* so that both centimeter units cancel out.

Example: One liter is exactly 1000 cm^3. How many cubic inches are there in 1.0 L?

Solution: We should know that
$1000\ cm^3 = 1\ L$

From a reference table we find,
1 in. = 2.54 cm

Setting up the factors we find,

$$1.0\ \cancel{L} \times \frac{1000\ \cancel{cm} \times \cancel{cm} \times \cancel{cm}}{1\ \cancel{L}} \times \frac{1\ in.}{2.54\ \cancel{cm}} \times \frac{1\ in.}{2.54\ \cancel{cm}} \times \frac{1\ in.}{2.54\ \cancel{cm}} = 61\ in.^3$$

(The answer has 2 significant digits since our given 1.0 L contained two significant digits.)

As you become more comfortable with the concept of unit cancellation you will find that it is a very handy tool for solving problems. By knowing the units of your given measurements, and by focusing on the units of the desired answer you can derive a formula and correctly calculate an answer. This is especially useful when you've forgotten, or never knew, the formula!

Example: Even though you may not know the exact formula for solving this problem, you should be able to match the units up in such a way that only your desired unit does not cancel out.

What is the volume in liters of 1.5 moles of gas at 293 K and 1.10 atm of pressure?
The ideal gas constant is $\frac{0.0821\ L \cdot atm}{mol \cdot K}$

Solution: It is not necessary to know the formula for the ideal gas law to solve this problem correctly. Working from the constant, since it sets the units, we need to cancel out every unit except L. Doing this shows us that moles and Kelvins need to be in the numerator and atmospheres in the denominator.

$$\frac{0.821\ L \cdot \cancel{atm}}{mol \cdot \cancel{K}} \times \frac{1.5\ \cancel{mol}}{} \times \frac{293\ \cancel{K}}{} \times \frac{}{1.10\ \cancel{atm}} = 33\ L$$

(2 significant digits since our least accurate measurement has only 2 sig. digs.)

DIMENSIONAL ANALYSIS PROBLEMS

Conversions Factors

1 hr = 60 min	1 min = 60 sec	1 ton = 2000 lbs	7 days = 1 week
24 hrs = 1 day	1 kg = 2.2 lbs	1 gal = 3.79 L	264.2 gal = 1 cubic meter
1 mi = 5,280 ft	1 kg = 1000 g	1 lb = 16 oz	20 drops = 1 mL
365 days = 1 yr	52 weeks = 1 yr	2.54 cm = 1 in	1 L = 1000 mL
0.621 mi = 1.00 km	1 yd = 36 inches	1 cc is 1 cm^3	1 mL = 1 cm^3

DIRECTIONS: Solve each problem using dimensional analysis. Every number must have a unit. Work must be shown. Conversion factors are given below

1.) How many miles will a person run during a 10 kilometer race?

2.) The moon is 250,000 miles away. How many feet is it from earth?

3.) A family pool holds 10,000 gallons of water. How many cubic meters is this?

4.) The average American student is in class 330 minutes/day. How many hours/day is this?

How many seconds is this?

5) How many seconds are there in 1 year?

6) Lake Michigan holds 1.3×10^{15} gallons of water. How many liters is this?

7) Pepsi puts 355 ml of pop in a can. How many drops is this?

How many cubic meters is this?

8) Chicago uses 1.2×10^9 gallons of water /day. How many gallons per second must be pumped from the lake every second to supply the city?

9) Sixty miles/ hour is how many ft/sec?

10) Lake Michigan holds 1.3×10^{15} gallons of water. If just Chicago removed water from the lake and it never rained again, how many days would the water last? Chicago uses 1.2×10^9 gallons of water /day

11). How many minutes are in 180.0 days?

12). If a person weighs 125 lbs, 8 oz., how many mg does s/he weigh?

13). The distance from Santa Maria to Los Alamos is 16.25 mi. What is the distance in cm?

14). Santa Maria has an elevation of 6.30×10^5 mm. How many km is this elevation?

15). If a projectile travels 3.00×10^3 feet in one second, how far will it travel in 18 minutes?

16). A small herd of cattle consumes fourteen bales of hay in two weeks. How many bales will this herd consume in a year?

17). During the previous year, Zach's weather station measured 0.8 yards of rain. Express this amount in cm.

18). If a swimmer swims 85.4 yards in five minutes, how many meters will s/he swim in 70.0 seconds?

19). Saffron costs $368.00 per ounce. Determine how many grams you can purchase for $15.00.

20). How many grams are equivalent to 1.80×10^{-4} tons? (English tons)

21). A gas station is charging $1.299 per gallon of gas. What would be the price for a liter of gas?

22). Determine the number of years in 8.35×10^{6} minutes.

23). A quart of a liquid has a mass of 2.70 kilograms. How many quarts will take to weigh 100.0 pounds?

24). Sixty-two months is equivalent to how many seconds?

25). A car consumes 25.00 gallons of fuel when driving a distance of 400.0 km. How many gallons will it consume when driving 250.0 miles?

26). 0.0054 weeks is equivalent to how many minutes?

27). How many feet per second is a wave going if it travels a distance of one mile in 7.35 seconds?

Dimensional Analysis Word Problems

You must use the formal method of dimensional analysis as taught in this class in order to get credit for these solutions (one point for each correct solution). Later in the course you may use any method of dimensional analysis to solve this type of problem.

1. Every three times I clean my bedroom, my mother makes me an apple pie. I cleaned my bedroom 9 times. How many apple pies does she owe me? (What? Your mother doesn't reward you for cleaning your bedroom? Aren't there child labor laws? To make up for that injustice, you may have this very easy extra credit problem.)

2. A chemistry teacher working at a golf camp during the summer found a liquid, which caused him to slice ball after ball into the water without disturbing him at all. He thought that this was an important liquid to identify so he set out to determine its density. He found that a sample of the liquid had a mass equal to 455 golf balls and occupied a volume of 620 water cups that he obtained at the 7^{th} hole. Each golf ball massed 50 g and the water cups at the 7^{th} hole of the golf course held 45 mL each. What is the density of the unknown liquid?

3. A Wilton High School senior was applying to college and wondered how many applications she needed to send. Her counselor explained that with the excellent grade she received in chemistry she would probably be accepted to one school out of every three to which she applied. [*3 applications = 1 acceptance*] She immediately realized that for each application she would have to write 3 essays, [*1 application = 3 essays*] and each essay would require 2 hours work *[1 essay = 2 hours*]. Of course writing essays is no simple matter. For each hour of serious essay writing, she would need to expend 500 calories [*1 hour = 500 calories*] which she could derive from her mother's apple pies [1 pie = 1000 calories]. How many times would she have to clean her room in order to gain acceptance to 10 colleges? Hopefully you didn't skip problem No 1. I'll help you get started.... 10 acceptances [ ] [ ] etc.

4. How much force, in g cm / s^2 , is exerted by a golf ball described in problem 2 striking a tree while accelerating at 20 cm / s^2 ? Show how you can solve this problem without knowing that F = m a. Explain your solution.

5. Because you never learned dimensional analysis, you have been working at a fast food restaurant for the past 35 years wrapping hamburgers. Each hour you wrap 184 hamburgers. you work 8 hours per day. you work 5 days a week. you get paid every 2 weeks with a salary of $840.34. How many hamburgers will you have to wrap to make your first one million dollars? [You are in a closed loop again. If you can solve the problem, you will have learned dimensional analysis and you can get a better job. But, since you won't be working there any longer, your solution will be wrong. If you can't solve the problem, you can continue working which means the problem is solvable, but you can't solve it. We have decided to overlook this impasse and allow you to solve the problem as if you had continued to wrap hamburgers.]

Dimensional Analysis Worksheet

1. Use Dimensional Analysis to solve the following problems. Use appropriate sig figs.
   a. How many seconds old are you? (Express with 2 sig figs in scientific notation.)
   b. Convert your distance from school to home from miles to inches. (Express with 2 sig figs in scientific notation.)
   c. How many kilometers is it from your house to school? (Express with 2 sig figs in scientific notation.)
   d. A person's weight is 154 pounds. Convert this to kilograms. (1 lbs. = 454 grams)
   e. An aspirin tablet contains 325 mg of acetaminophen. How many grains is this equivalent to? (1 gram = 15.432 grains)
2. Solve using the conversion factors that are listed in the table below. Answer with appropriate sig figs.
   a. Your cruise ship is leaving for a 610-league adventure. How many nautical miles is this?
   b. Later the ship is discovered at 38 fathoms deep under water. Convert this to meters.
   c. Fortunately you survived! You are stranded on a deserted island that is located 12.5 degrees north of the equator. How many kilometers is this?
   d. If you are rationed to 32 gills of fresh water a day. How many liters is this?
   e. The island has an area of 3.5 townships. How many square yards is this? (Please use scientific notation.)
   f. To reach the top of a palm tree for a coconut you will have to climb 7.4 meters. How many hands is this?
   g. The island is rich with hot chile peppers. You can collect 1.6 pecks a day. How many liters could you collect in **1 week**?
3. More conversions with specific information given.
   a. Each liter of air has a mass of 1.80 grams. How many liters of air are contained in 2.5 $x10^3$ kg of air?
   b. 16.0 grams of food contain 130 calories. How many grams of food would you need in order to consume 2150 calories?
   c. The cost of 1.00 Liters of gas is 26.9 cents. How many dollars will 12.0 gallons cost?
   d. Light travels 186 000 miles / second. How long is a light year in meters? (1 light year is the distance light travels in one year)
   e. 1 mole of Si atoms contains 6.02 $x10^{23}$ atoms. 6.02 $x10^{23}$ atoms of Si have a mass of 28.1 g. How many atoms of Si are contained in a computer chip that masses 38.02-mg?