Unit Conversion and Dimensional Analysis

Frequently in Chemistry you will be provided with data describing a particular quantity in a certain unit of measurement, and you will be required to convert it to a different unit which measures the same quantity. This process is frequently described as Unit Conversion. As an example, you may be given a measurement of length in centimeters which must be converted to meters. This worksheet includes the rules and some guidelines to help you with converting, density problems, stoichiometry problems, and concentration problems. This worksheet is not intended to help you with reading comprehension of word problems regarding these types of questions, just the mathematical application.

Rules

1.) Identify the **given** measurement.
2.) Identify the **unit** that the measurement must be converted to.
3.) Use **conversion factors** (relationship between two units) that link your given unit to your final unit.
4.) Perform the mathematical calculations.
5.) Do **not** forget to apply significant figures to your final answer.

Guidelines

1.) When converting a single unit, such as converting from centimeters to meters, the given should also be a single unit as well. It can become more difficult by starting with the conversion factor: (100 cm / 1 m). Even if you know a dozen = 12, the relationship cannot be applied if you do not know how many dozen you care about.
2.) When only a single unit given, it should be written over 1. For example, 56.93 cm should be written as 56.93 cm / 1. Units lacking a number are assumed to be 1. If we were given 1.193 g / ml, we would write this as 1.193 g / 1 ml .
3.) Any relationship between two units can potentially be utilized as a conversion factor: density relates mass and volume while molar mass relates moles and mass. Express these conversion factors as a fraction in the dimensional analysis.
4.) A conversion factor can be written in **two** different ways. For example, converting centimeters and meters, we can use the conversion factor (100 cm / 1 m) or (1 m / 100 cm). The unit you want to remove from the problem should be placed **opposite** of the original. So, to convert from cm to m, cm is your given unit, and the cm should be in the bottom to denominator out cm from the problem.

5.) The math should be the **last** thing you do. By first cancelling units, so that your final unit is the only one, you may easily check that the conversion has been set up correctly. The math calculation will follow this.
6.) Standardized conversion factors are **never** used to calculate significant figures. Multiplying by the conversion factor (100 cm / 1 m) will not affect your significant digits.

<u>Example</u>

Problem: Convert: 56.93 cm to m

Solution:

1.) The given measurement is 56.93 cm.
2.) The measurement must be converted to meters.
3.) The conversion factor(s) we need to use either has to directly relate cm and m, or chain to cancel all units except m. Luckily, we know a direct one: 100 cm is equal to 1 m. cm should be in the denominator to cancel with the original cm.
4.) 56.93 ~~cm~~ m 56.93 m
------------ X --------- = ---------- = .5693 m (significant figures applied)

<u>Practice Problems: Answers</u>

1.	87680 g	11.	5.055 m	21.	2.133 L	31.	8.177×10^{-5}

Density Practice Problems

1.

Molecule / Mole Stoichiometry Example

Problem: Based on the balanced chemical equation: $C + O_2 \rightarrow CO_2$, how many molecules of carbon dioxide could be produced from 20 atoms of carbon in the presence of excess oxygen?

Solution:

1.) The given measurement is the 20 carbon atoms.
2.) This must be converted to molecules of carbon dioxide.
3.) The conversion factor has to relate carbon atoms and carbon dioxide molecules. Luckily, one can use a balanced chemical equation, such as the one above, to determine a conversion factor between the two different substances. The ratio is 1 C : 1 CO_2, and the carbon be in the denominator of the fraction to cancel the given carbon unit.
4.) $\frac{20\ \cancel{C}}{1} \times \frac{1\ CO_2}{1\ \cancel{C}} = \frac{20\ CO_2}{1} = 20\ CO_2$ molecules (significant figures applied)

Molecule / Mole Stoichiometry Practice Problems

Note: Be specific when writing conversion factors representing chemicals. You should include not only the unit of measure, but also the identity of the chemical itself.

Note: When taking two reactants to see how much product they can produce, it is necessary to check for the limiting reagent, the one you have less of after converting to moles and accounting for the ratio in which it reacts.

$$2\ N_2O_5 \rightarrow 2\ N_2 + 5\ O_2$$

1.	How many molecules of nitrogen gas are produced from a reaction yielding 225 molecules of oxygen gas?
2.	How many molecules of dinitrogen pentoxide are required to produce 164 molecules of nitrogen gas for your gas molecule collection?
3.	When 40 molecules of oxygen gas are produced, how many molecules of nitrogen gas byprta- 1uceTET*nBT1 0.7 452.59 27.6 reWtrogrogeecule collta- 1uceTET*nBT1223.13 452

$$2\ Fe(NO_3)_3 \quad + \quad 3\ MgO \quad \rightarrow \quad Fe_2O_3 \quad + \quad 3\ Mg(NO_3)_2$$

16.	In order to obtain 132.843 moles of magnesium nitrate, how many moles of magnesium oxide must be reacted?
17.	After a reaction runs to completion, you obtain 27.13 moles of magnesium nitrate. How many moles of iron(III)nitrate were consumed?
18.	Determine how many moles iron(III)nitrate are required to synthesize 421.0 moles of iron(III)oxide.
19.	You react 7.23 moles of iron(III)nitrate and 11.48 moles of magnesium oxide in the magnesium nitrate lab you set up in your bathroom, producing how many moles of iron(III)oxide waste?
20.	How many moles of magnesium nitrate product was formed in problem 19?

$$4\ (NH_4)_3N \quad + \quad 3\ Cr(CrO_4)_2 \quad \rightarrow \quad 6\ (\qquad\qquad 6\ ($$

$$AlCl_3 + 3\,H_2O \rightarrow Al(OH)_3 + 3\,HCl$$

31.	You accidently add an unknown mass of aluminum chloride into your reaction mixture containing 47.0 grams of water. On completion, your reaction mixture yields 47.00 grams of aluminum hydroxide. Determine the mass of aluminum chloride.
32.	You trap 6.99 grams of hydrogen chloride from a reaction. How much aluminum chloride was required to produce this quantity?
33.	In a misguided attempt to completely remove any water from your favorite cup, you add 40.00 grams of aluminum chloride. On removal, 14.328 grams of aluminum hydroxide are recovered. How much hydrogen chloride is produced in what is no longer your morning coffee mug?
34.	You isolate 9.35 grams of aluminum hydroxide and 9.35 grams of hydrogen chloride from a reaction mixture. What is the minimum mass of each reactant necessary to produce this combination?

Molecule / Mole Stoichiometry Practice Problems: Solutions

1.	90 N_2 molecules	21.	1868.1 g $(NH_4)_2CrO_4$
2.	164 N_2O_5 molecules	22.	1.333 moles $Cr(CrO_4)_2$
3.	16 N_2 molecules	23.	0.021 moles $(NH_4)_2CrO_4$
4.	374 N_2O_5 molecules	24.	181000 grams $(NH_4)_3N$ and 567000 grams $Cr(CrO_4)_2$