Solutions to:

Units and Calculations Homework Problem Set
Chemistry 145, Chapter 1

1. Give the name and abbreviation of the SI Unit for:

a. Length	meter	m
b. Mass	kilogram	kg
c. Time	second	s
d. Electric Current	amp	A
e. Temperature	kelvin	K

2. Give the abbreviation and describe what the following units are used to measure:

a. meter		m	length
b. liter		L	volume
c. cubic centimeter		cm^3	volume
d. milliliter	mL	volume	
e. degree Celcius		^oC	temperature
f. kelvin		K	temperature (absolute)

3. Give the name and the abbreviation (without looking in the book) of the SI or metric prefix for:

a. 10^{-12}	pico	p
b. 10^6	mega	M
c. 10^{-9}	nano	n
d. 10^{-2}	centi	c
e. 10^{-3}	milli	m
f. 10^9	giga	G
g. 10^3	kilo	k
h. 10^{-6}	micro	m

4. Express the following numbers in scientific notation with the appropriate number of significant figures:
   a. 157000000 = 1.57×10^9
   b. 41410= 4.151×10^4
   c. 0.00095162= 9.416×10^{-4}
   d. 746.5×10^6= 7.465×10^8

Perform the following calculations and give the answer in scientific notation with the correct number of significant figures. (Note: The software used to perform these calculations does not round significant figures. The first answer given is the result of the calculation. The second number is appropriately rounded)

a. $30.84 + 9.74 = 40.58000000$ $4.058\cdot10^{1}$

b. $30.84 + 9.74487 = 40.58487000$ $4.058\cdot10^{1}$

c. $30.845 + 9.74 = 40.58500000$ $4.058\cdot10^{1}$

d. $30.845 + 9.75 = 40.59500000$ $4.060\cdot10^{1}$

e. $145 + 1.54\cdot10^{-6} = 145.00000154$ $1.45\cdot10^{2}$

f. $40.79 - 1.18432 = 39.60568000$ $3.960\cdot10^{1}$

g. $1.43\cdot0.848 = 1.21264000$ 1.21

h. $1.43\cdot0.84828 = 1.21304040$ 1.21

i. $136\cdot3.0 = 408.00000000$ $4.1\cdot10^{2}$

j. $(7.601\cdot10^{7})\cdot(8.09\cdot10^{-4}) = 6.14920900\cdot10^{4}$ $6.149\cdot10^{4}$

k. $70.2^{2} = 4.92804000\cdot10^{3}$ $4.93\cdot10^{3}$

l. $94773^{\frac{1}{2}} = 307.85223728$ $3.0785\cdot10^{2}$

6. Perform the following mathematical operations and give the answer with the correct number of significant figures:

a. $$\frac{(9.008\cdot10^{4})\cdot(6.5227\cdot10^{7})}{(6.53\cdot10^{-4})} = 8.99792980\cdot10^{15}$$ $9.00\cdot10^{15}$

b $$\sqrt{(1.460\cdot10^{3})\cdot53.1209} = 278.48970178$$ 278.5

c. $$57.429^{\frac{1}{2}} = 7.57819240$$ 7.5782

d. $$\frac{7.1\cdot10^{2} + 924}{7.508\cdot10^{4}} = 0.02176345$$ $2.18\cdot10^{-2}$

(note: first add the numerator to get 1634, but only has 3 SF.)

7. Perform the following unit conversions. Express your answers in scientific notation with the appropriate number of significant figures. (NOTE: the answers given below do not have the correct number of significant figures, but you should be able to determine this by now. Remember that most of these conversion factors are exact numbers, so the answer is limited by the number of significant figures as is given in the problem.)

a. Convert 49.01 inches into: feet, meters, centimeters, millimeters and kilometers.

Solutions	**Worked out**
$49.01\cdot in = 4.08416667\cdot ft$	$1\cdot ft = 12.00000000\cdot in$ $(49.01\cdot in)\cdot\left(\frac{1\cdot ft}{12\cdot in}\right) = 4.08416667\cdot ft$
$49.01\cdot in = 1.24485400\cdot m$	$1\cdot m = 39.37007874\cdot in$ $(49.01\cdot in)\cdot\left(\frac{1\cdot m}{39.37007874\cdot in}\right) = 1.24485400\cdot m$
$49.01\cdot in = 124.48540000\cdot cm$	$1\cdot in = 2.54000000\cdot cm$ $(49.01\cdot in)\cdot\left(\frac{2.54\cdot cm}{1\cdot in}\right) = 124.48540000\cdot cm$
$49.01\cdot in = 1.24485400\cdot 10^{3}\cdot mm$	$1\cdot in = 25.40000000\cdot mm$ $(49.01\cdot in)\cdot\left(\frac{25.4\cdot mm}{1\cdot in}\right) = 1.24485400\cdot 10^{3}\cdot mm$
$49.01\cdot in = 0.00124485\cdot km$	$1\cdot km = 1.00000000\cdot 10^{3}\cdot m$ $1\cdot m = 39.37007874\cdot in$ $(1\cdot km)\cdot\left(\frac{1\cdot 10^{3}\cdot m}{1\cdot km}\right)\cdot\left(\frac{39.37007874\cdot in}{1\cdot m}\right) = 3.93700787\cdot 10^{4}\cdot in$ $(49.01\cdot in)\cdot\left(\frac{1\cdot km}{3.93700787\cdot 10^{4}\cdot in}\right) = 0.00124485\cdot km$

b. Convert 5480 feet into miles, kilometers and meters.

Solutions	**Worked out**
$5480\cdot ft = 1.03787879\cdot mi$	$1\cdot mi = 5280.00000000\cdot ft$ $(5480\cdot ft)\cdot\left(\frac{1\cdot mi}{5280\cdot ft}\right) = 1.03787879\cdot mi$
$5480\cdot ft = 1.67030400\cdot km$	$1\cdot km = 3280.83989501\cdot ft$ $(5480\cdot ft)\cdot\left(\frac{1\cdot km}{3280.83989501\cdot ft}\right) = 1.67030400\cdot km$
$5480\cdot ft = 1.67030400\cdot 10^{3}\cdot m$	$1\cdot m = 3.28083990\cdot ft$ $(5480\cdot ft)\cdot\left(\frac{1\cdot m}{3.28083990\cdot ft}\right) = 1.67030400\cdot 10^{3}\cdot m$

c. Convert 542 meters into kilometers, centimeters, millimeters, micrometers, and nanometers.

$\mu m \equiv 10^{-6}\cdot m$

$nm \equiv 10^{-9}\cdot m$

Solutions	**Worked out**
$5.42\cdot m = 0.00542000\cdot km$	$1\cdot km = 1000.00000000\cdot m$ $(5.42\cdot m)\cdot\left(\frac{1\cdot km}{1000\cdot m}\right) = 0.00542000\cdot km$
$5.42\cdot m = 542.00000000\cdot cm$	$1\cdot cm = 0.01000000\cdot m$ $(5.42\cdot m)\cdot\left(\frac{1\cdot cm}{10^{-2}\cdot m}\right) = 542.00000000\cdot cm$
$5.42\cdot m = 5.42000000\cdot 10^{3}\cdot mm$	$1\cdot mm = 0.00100000\cdot m$ $(5.42\cdot m)\cdot\left(\frac{1\cdot mm}{10^{-3}\cdot m}\right) = 5.42000000\cdot 10^{3}\cdot mm$
$5.42\cdot m = 5.42000000\cdot 10^{6}\cdot \mu m$	$1\cdot \mu m = 1.00000000\cdot 10^{-6}\cdot m$ $(5.42\cdot m)\cdot\left(\frac{1\cdot \mu m}{10^{-6}\cdot m}\right) = 5.42000000\cdot 10^{6}\cdot \mu m$
$5.42\cdot m = 5.42000000\cdot 10^{9}\cdot nm$	$1\cdot nm = 1.00000000\cdot 10^{-9}\cdot m$ $(5.42\cdot m)\cdot\left(\frac{1\cdot nm}{10^{-9}\cdot m}\right) = 5.42000000\cdot 10^{9}\cdot nm$

d. Convert 98.6 ^oF into ^oC and K.

Convert ^oF to ^oC: $(98.6 - 32)\cdot\frac{5}{9} = 37.00000000$

Convert ^oC to K: $37 + 273.15 = 310.15000000$

e. Convert 65 miles per hour into: km per hour and m s^{-1}.

Solutions

$65\cdot\frac{mi}{hr} = 104.60736000\,\bullet\frac{km}{hr}$

$65\cdot\frac{mi}{hr} = 29.05760000\bullet m\bullet sec^{-1}$

Worked out

$1\cdot km = 0.62137119\,\bullet mi$

$65\cdot\frac{mi}{hr}\cdot\left(\frac{1\cdot km}{0.62137119\cdot mi}\right) = 104.60736038\,\bullet\frac{km}{hr}$

$1\cdot mi = 1.60934400\bullet 10^{3}\,\bullet m$

$1\cdot hr = 3.60000000\bullet 10^{3}\,\bullet sec$

$65\cdot\frac{mi}{hr}\cdot\left(\frac{1.609\cdot 10^{3}\cdot m}{1\cdot mi}\right)\cdot\left(\frac{1\cdot hr}{3.6\cdot 10^{3}\cdot sec}\right) = 29.051\bullet m\bullet sec^{-1}$

f. Convert 3.15 m^2 into ft^2, in^2, and cm^2

Solutions

$3.15\cdot m^{2} = 33.90631781\,\bullet ft^{2}$

$3.15\cdot m^{2} = 4.88250977\bullet 10^{3}\,\bullet in^{2}$

$3.15\cdot m^{2} = 3.15000000\bullet 10^{4}\,\bullet cm^{2}$

Worked out

$1\cdot m = 3.28083990\,\bullet ft$

$3.15\cdot m^{2}\cdot\left(\frac{3.2808\cdot ft}{1\cdot m}\right)^{2} = 33.90549322\,\bullet ft^{2}$

$1\cdot m = 39.37007874\,\bullet in$

$3.15\cdot m^{2}\cdot\left(\frac{39.37\cdot in}{1\cdot m}\right)^{2} = 4.88249024\bullet 10^{3}\,\bullet in^{2}$

$1\cdot m = 100.00000000\,\bullet cm$

$3.15\cdot m^{2}\cdot\left(\frac{100\cdot cm}{1\cdot m}\right)^{2} = 3.15000000\bullet 10^{4}\,\bullet cm^{2}$

g. Convert 250 cm^3 into in^3, m^3, L and mL

Solutions	**Worked out**
$250 \cdot cm^3 = 15.25593602 \cdot in^3$	$1 \cdot in = 2.54000000 \cdot cm$ $250 \cdot cm^3 \cdot \left(\frac{1 \cdot in}{2.54 \cdot cm}\right)^3 = 15.25593602 \cdot in^3$
$250 \cdot cm^3 = 2.50000000 \cdot 10^{-4} \cdot m^3$	$1 \cdot m = 100.00000000 \cdot cm$ $250 \cdot cm^3 \cdot \left(\frac{1 \cdot m}{100 \cdot cm}\right)^3 = 2.50000000 \cdot 10^{-4} \cdot m^3$
$250 \cdot cm^3 = 0.25000000 \cdot liter$	$1 \cdot liter = 1000.0000000 \cdot cm^3$ $250 \cdot cm^3 \cdot \left(\frac{1 \cdot liter}{1000 \cdot cm^3}\right) = 0.25000000 \cdot liter$
$250 \cdot cm^3 = 250.00000000 \cdot mL$	$1 \cdot mL = 1.00000000 \cdot cm^3$ $250 \cdot cm^3 \cdot \left(\frac{1 \cdot mL}{1 \cdot cm^3}\right) = 250.00000000 \cdot mL$

8. In the movie Goldfinger, James Bond foils a plot to break into Fort Knox. 007 does some quick mental calculations to determine the feasibility of removing the gold. If the price of gold is $14.00 per troy ounce (31.1035 grams), what is the mass (in kg) of 1 million dollars of gold? What is the volume of 1 million dollars of gold in mL, L, and m^3.

$dollar := 1$

First how much does 1 million dollars of gold weigh at $14.00 per troy ounce.

$troy\_ounce := 14 \cdot dollar$

$$\left(1 \cdot 10^{6} \cdot dollar\right) \cdot \left(\frac{1 \cdot troy\_ounce}{14 \cdot dollar}\right) = 7.14285714 \cdot 10^{4} \cdot troy\_ounce$$

$troy\_ounce := 31.1035 \cdot gm$

$$7.14285714 \cdot 10^{4} \cdot troy\_ounce \cdot \left(\frac{31.1035 \cdot gm}{1 \cdot troy\_ounce}\right) \cdot \left(\frac{1 \cdot kg}{10^{3} \cdot gm}\right) = 2.22167857 \cdot 10^{3} \cdot kg$$

Note, this is:

$$2.22 \cdot 10^{3} \cdot kg = 4.89426222 \cdot 10^{3} \cdot lb$$

$$2.22 \cdot 10^{3} \cdot kg = 2.44713057 \cdot ton$$

The volume of this gold may be determined from the density of gold (19.32 g/cm^3). You will have to look this up somewhere. (Your textbook is a good place to start, another good reference is the CRC Handbook of Chemistry and Physics. You should know where this is in the Library)

$$density = \frac{mass}{volume}$$

$density_{Ag} := 19.32 \cdot gm \cdot cm^{-3}$

$mass_{Ag} := 2.22 \cdot 10^{3} \cdot kg$

$$volume_{Ag} := \frac{mass_{Ag}}{density_{Ag}}$$

$volume_{Ag} = 1.14906832 \cdot 10^{5} \cdot mL$

$volume_{Ag} = 114.90683230 \cdot liter$

$volume_{Ag} = 0.11490683 \cdot m^{3}$

A few notes on Mathcad, the program used to prepare these answers. This will help you learn how to read these documents.

The equals sign. The bold (**=**) is for "symbolic" math, it just shows an equation like a book would. The equals with a colon (:=) is for "defining" a variable. The regular equals (=) is for calculating a value.

Units. Mathcad automatically calculates units and displays answers using SI units, unless told otherwise. I will sometimes show each step in a unit conversion, but after the first chapter, you should be comfortable with this and I will just display the results.

Mathcad does not round. Since properly rounding each answer is a lot of work, you are responsible for checking this.

9. The following experiment is performed with an unknown liquid. The liquid is added to a graduated cylinder with a mass of 54.6789 grams. After 25.00 mL of the liquid is added to the cylinder, the mass is 79.6789 grams. Is the liquid water? How do you know? If it is not water, what could it be?

Information given in the problem:

$$mass_{cylinder} := 54.6789 \cdot gm$$

$$volume_{liquid} := 25.00 \cdot mL$$

$$mass_{total} := 79.6421 \cdot gm$$

From the total mass and the mass of the cylinder you can determine the mass of the liquid:

$$mass_{liquid} := mass_{total} - mass_{cylinder}$$

$$mass_{liquid} = 24.96320000 \cdot gm$$

Now that the mass of the liquid and the volume of the liquid are known, the density may be determined. This is useful because the density of a compound is constant and may be compared with tables of known values.

$$density = \frac{mass}{volume}$$

$$density_{liquid} := \frac{mass_{liquid}}{volume_{liquid}}$$

$$density_{liquid} = 0.99852800 \cdot gm \cdot mL^{-1}$$

The density of water at 25 ^{o}C, from the CRC Handbook of Chemistry and Physics, is 0.99707 g/mL. Since this is very close to the density of the unknown liquid, the unknown COULD be water (It does not have to be since some other liquid could have the same density).

Now repeat the above calculations for the second unknown.

The experiment is repeated with a second liquid, after 20.3 mL of this liquid is added the mass of the cylinde
71.7364 grams. Is the second liquid ethanol? How do you know? If it is not ethanol, what could it be?

Information given in the problem:

$$mass_{cylinder} := 54.6789 \cdot gm$$

$$volume_{liquid} := 20.3 \cdot mL$$

$$mass_{total} := 71.7364 \cdot gm$$

From the total mass and the mass of the cylinder you can determine the mass of the liquid:

$$mass_{liquid} := mass_{total} - mass_{cylinder}$$

$$mass_{liquid} = 17.05750000 \cdot gm$$

Now that the mass of the liquid and the volume of the liquid are known, the density may be determined. This is useful because the density of a compound is constant and may be compared with tables of known values.

$$density = \frac{mass}{volume}$$

$$density_{liquid} := \frac{mass_{liquid}}{volume_{liquid}}$$

$$density_{liquid} = 0.84027094 \cdot gm \cdot mL^{-1}$$

The density of ethanol at 20 ^{o}C, from the CRC Handbook of Chemistry and Physics, is 0.7893 gm/ mL. This is not consistant with the value calculated in this problem. To find possible compounds, glance through a table of densities and find something with a density close to this experimental value.

This problem set and the solutions were prepared by:

Scott Van Bramer
Department of Chemistry
Widener University
Chester, PA 19013
svanbram@science.widener.edu
http://science.widener.edu/~svanbram