Conversions of Units Key

C1WS5K By: Dr. Robert Belford

Part 1: Conversion Factors

Allow a measurement to be transformed from one scale to another.

Three Basic Types

A. Different prefixes of same base scale (cm -> Km

B. Conversions between scales (cm -> in)

C. Physical Constants d=M/V

A. Different Prefixes of same base scale.

Basic Technique: Set up two equivelence statements

How many micrograms are in a kilogram?
Set up conversion factors based on an equivalence statements.

$1kg = 10^3 g \text{ and } 1\mu g = 10^{-6} g$

$so,$ this gives two conversion factors

$$\left(\frac{10^3 g}{1kg}\right) and \left(\frac{1\mu g}{10^{-6} g}\right)$$

Use Factor-Label Method

$$1kg\left(\frac{10^3 g}{1kg}\right)\left(\frac{1\mu g}{10^{-6} g}\right) = 10^{3-(-6)}\mu g = 10^9 \mu g$$

Example: Convert 32.4 ng to Mg.

$$32.4ng\left(\frac{10^{-9} g}{ng}\right)\left(\frac{Mg}{10^6 g}\right) = 32.4x10^{(-9-6)} Mg = 32.4x10^{-15} Mg = 3.24x10^{-14} Mg$$

Problems: Solve the following:

1.) 56.4Tbytes = ___Mbytes

$$56.4Tbytes\left(\frac{10^{12} bytes}{Tbytes}\right)\left(\frac{Mbytes}{10^6 bytes}\right) = 56.4x10^{(12-6)} Mbytes = 56.4x10^6 Mbytes = 5.64x10^7 Mbytes$$

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2.) 34.6nsec = ___Gsec

$$34.6n\sec\left(\frac{10^{-9}\sec}{n\sec}\right)\left(\frac{G\sec}{10^{9}\sec}\right)=34.6x10^{(-9-9)}G\sec=34.6x10^{(-18)}G\sec=3.46x10^{(-17)}G\sec$$

3.) 4.0Mg = ___ kg

$$4.0Mg\left(\frac{10^{6}g}{Mg}\right)\left(\frac{kg}{10^{3}g}\right)=4.0x10^{(6-3)}kg=4.0x10^{3}kg$$

Advanced Technique: Set up 1 equivalence statement
How many micrograms are in a kilogram?
Set up a conversion factor based on an equivalence statement.

$$1\mu g=10^{-6}g \quad \therefore \quad 1g=10^{6}\mu g$$

$$1kg=10^{3}g \quad \therefore \quad 1g=10^{-3}kg$$

so, this gives two conversion factors

$$a.)\quad \frac{1g}{1g}=1=\frac{10^{6}\mu g}{10^{-3}kg}=\frac{10^{9}\mu g}{kg}$$

or

$$b.)\quad \frac{1g}{1g}=1=\frac{10^{-3}kg}{10^{6}\mu g}=\frac{10^{-9}kg}{\mu g}$$

Use the ratio which has the starting unit in the denominator and ending unit in the numerator.

Use (a.) to convert kilograms to micrograms
(b.) to convert micrograms to kilograms

Example: Convert 32.4 ng to Mg.

$$1g=10^{-6}Mg=10^{9}ng$$

$$32.4ng\left(\frac{10^{-6}Mg}{10^{9}ng}\right)=32.4x10^{(-6-9)}Mg=32.4x10^{-15}Mg=3.24x10^{-14}Mg$$

Conversion Factors and Scientific Notation

Convert $3.57x10^{14}$ μl to ml

$$3.57x10^{14}\mu l\left(\frac{10^{3}ml}{10^{6}\mu l}\right)=3.57x10^{(14+3-6)}ml=3.57x10^{11}ml$$

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Problems: Solve the following

1.) Convert $4.337 x 10^{14}$ Tl to μl

$$4.337x10^{14}Tl\left(\frac{10^{6}\,\mu l}{10^{-12}Tl}\right)=4.337x10^{(14+12+6)}\,\mu l=4.337x10^{32}\,\mu l$$

2.) Convert $4.78 x 10^{24}$ fg to Mg

$$4.78x10^{24}\,fg\left(\frac{10^{-6}\,Mg}{10^{15}\,fg}\right)=4.78x10^{(24-15-6)}\,Mg=4.78x10^{3}\,Mg$$

3.) Convert $2.00 x 10^{-4}$ μsec to psec

$$2.00x10^{-4}\,\mu\sec\left(\frac{10^{12}\,p\sec}{10^{6}\,\mu\sec}\right)=2.00x10^{(-4+12-6)}\,p\sec=2.00x10^{2}\,p\sec$$

B. Conversions between different scales:

YOU MUST SHOW WORK AS SOME CALCULATORS AUTOMATICALLY DO CONVERSIONS

You need equivalence statements between different units.

KNOW: 2.54cm=1in (exact) (Metric length to English Length)
1ml = $1cm^3$ (Metric volume to Metric length cubed)

Note* Many of these are not exact, see back cover of book.

How many dm are in an object which is 2.45 feet long?
given 12in = 1 ft,

$$2.450\,ft\left(\frac{12in}{ft}\right)\left(\frac{2.54cm}{in}\right)\left(\frac{10^{1}\,dm}{10^{2}\,cm}\right)=7.4676dm=7.468dm$$

How many gallons are in a cuboid can that is 2.05 ft wide, 12.4 inches long and 1.30 yards deep?

Given: 4 qt = 1 gal, 1.057qt=1L, 12in = 1 ft, 3 ft = 1 yd:

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$$2.05\,ft\left(12.4in\right)\left(1.30\,yd\right)\left(\frac{3\,ft}{yd}\right)\left(\frac{12in}{ft}\right)^2\left(\frac{2.54cm}{in}\right)^3\left(\frac{1mL}{1cm^3}\right)\left(\frac{1L}{1000mL}\right)\left(\frac{1.057qt}{1L}\right)\left(\frac{gal}{4qt}\right)=61.8gal$$

Problems:

1.) How many square inches are in a rectangle which is 3.24ft by 2.67 yd?

$$3.24\,ft\left(2.67\,yd\right)\left(\frac{3\,ft}{yd}\right)\left(\frac{12in}{ft}\right)^2=3737.1456in^2=3740in^2$$

2.) How many cubic inches are in 1.00 mL?

$$1.00ml\left(\frac{cm^3}{1ml}\right)\left(\frac{in}{2.54cm}\right)^3=0.0610in^3$$

3.) How many cubic feet are in 1.00 TL?

$$1.00Tl\left(\frac{10^3\,mL}{10^{-12}\,TL}\right)\left(\frac{1cm^3}{1mL}\right)\left(\frac{in}{2.54cm}\right)^3\left(\frac{ft}{12in}\right)^3=3.53x10^{10}\,ft^3$$

4.) How many kL are in a cube which is $3.24x10^{21}$mm on each side?

$$\left(3.24x10^{21}\,mm\right)^3\left(\frac{10^2\,cm}{10^3\,mm}\right)^3\left(\frac{mL}{1cm^3}\right)\left(\frac{10^{-3}\,kL}{10^3\,mL}\right)=3.40x10^{55}\,kL$$

5.) How many square inches are in a rectangle which is $1.75x10^{11}$mm by $7.34x10^{-13}$km

$$1.75x10^{11}\,mm\left(7.34x10^{-13}\,km\right)\left(\frac{cm}{10mm}\right)\left(\frac{10^2\,cm}{10^{-3}\,km}\right)\left(\frac{in}{2.54cm}\right)^2=199in^2$$

6.) How many mL are in an cuboid that is $2.00x10^{21}$mm by $3.00x10^{2}$yard by $5.00x10^{18}$ft?

$$2.00x10^{21}\,mm\left(3.00x10^2\,yd\right)\left(5.00x10^{18}\,ft\right)\left(\frac{3\,ft}{yd}\right)\left(\frac{12in}{ft}\right)^2\left(\frac{1cm}{10mm}\right)\left(\frac{2.54cm}{1in}\right)^2\left(\frac{mL}{1cm^3}\right)=8.36x10^{44}\,mL$$

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C. Physical Constants

These are typically measured and have significant digits.

Density: Allows conversion from Mass to Volume.

D=M/V

How many pounds does a 61.8 gal container weight at a given temperature if water has a density of 0.98g/mL?

$$61.8gal\left(\frac{4qt}{gal}\right)\left(\frac{L}{1.057qt}\right)\left(\frac{1000mL}{L}\right)\left(\frac{0.98g}{mL}\right)\left(\frac{lb}{453.6g}\right)=505.27lb=510lb$$

Note the answer has 2 significant digits because of the density

Problems:

1.) If the density of gold is 19.3g/ml, what is it in lb/in^3?

$$\frac{19.3g}{mL}\left(\frac{mL}{cm^3}\right)\left(\frac{2.54cm}{in}\right)^3\left(\frac{lb}{453.59g}\right)=0.697\,{}^{lb}\!/_{in^3}$$

2.) What is the mass a cubic foot of mercury (d_{Hg}=13.6 g/ml), consider it to be 1.00 ft on each side

$$d=\frac{m}{V}\Rightarrow m=dV=\frac{13.6g}{mL}(1ft)^3\left(\frac{12in}{1ft}\right)^3\left(\frac{2.54cm}{in}\right)^3\left(\frac{mL}{1cm^3}\right)=385kg$$

3.) Osmium is the densest natural element with a density of 22.61 g/ml. What would be the mass of 1.00 gallon of osmium?

$$d=\frac{m}{V}\Rightarrow m=dV=\frac{22.61g}{mL}(1.00gal)\left(\frac{3.785l}{1gal}\right)\left(\frac{1000ml}{1l}\right)=85.6kg$$

4.) What volume of water would have the same mass as 1.00 gallon of osmium?

$$85.6kg\left(\frac{1L}{kg}\right)=85.6L$$

5.) What is the density of water in lb/in^3?

$$\frac{1g}{mL}\left(\frac{mL}{cm^3}\right)\left(\frac{2.54cm}{in}\right)^3\left(\frac{lb}{453.59g}\right)=0.0361\,{}^{lb}\!/\!{}_{in^3}$$

Specific Gravity: The specific gravity is the ration of the density of one substance to another. One of the advantages of specific gravity is that it has the same value, not matter what units were used in calculating it.

1.) Using densities in units of g/ml, calculate the specific gravity of gold?

$$\frac{19.3g/mL}{1g/mL}=19.3$$

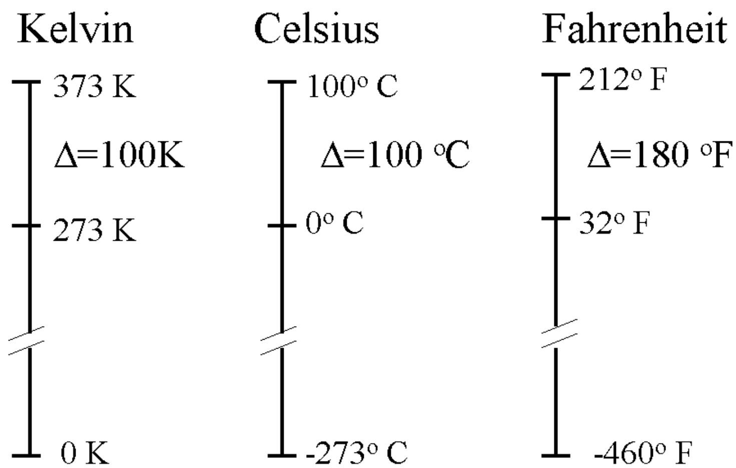
2.) Calculate the specific gravity of gold from densities in units of lb/in^3 (question 1 and 5 above).

$$\frac{0.697lb/in^3}{0.0361lb/in^3}=19.3$$

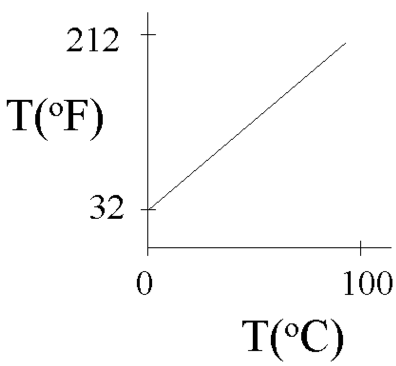
Part 2 Temperature Conversion and equation for a straight line

$T_C = T_K - 273.15$

Temperature Measurement



Temperature Conversions



$$y = mx + b$$

$$\begin{aligned} {}^{0}F &= \frac{212-32}{100-0}\,{}^{0}C + 32 \\ &= \frac{180}{100}\,{}^{0}C + 32 \\ &= \frac{9}{5}\,{}^{0}C + 32 \\ &= 1.8\,{}^{0}C + 32 \end{aligned}$$

Temperature Conversions

$$°C = \frac{1}{1.8}(°F - 32)$$

$$°F = 1.8(°C) + 32$$

At what Temperature do these scales converge?

-40°C=-40°F

Temperature Conversions

+40/-40 Method

1. Add 40 to number
2. If going from C to F, multiply by 1.8

   (the change is greater)

   If going from F to C, divide by 1.8

   (the change is smaller)
3. Subtract 40 from number

Convert 98.6°F to C° and K.

$$(98.6 + 40)\left(\frac{1}{1.8}\right) - 40 = 37.0°C$$

$$37.0 + 273.15 = 310.2K$$

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What is Absolute Zero in Fahrenheit?

$$0K = -273.15^{o}C$$

$$\left(-273.15 + 40\right)(1.8) - 40 = -459.67^{o}F$$

Problems:

1. El Azizia Libya is considered the hottest place on earth where the air temperature was 57.8^{o} C on September 13, 1922.

a. What is that temperature in Fahrenheit?

$$\left(57.8 + 40\right)1.8 - 40 = 136^{o}F$$

b. What is that temperature in Kelvin?

$$56.8 + 273.15 = 331K$$

2. Vostok station in Antarctica has the coldest temperature recorded on earth at -129^{o}F.

a. What is that temperature in ^{o}C?

$$\frac{\left(-129 + 40\right)}{1.8} - 40 = -89.4^{o}C$$

b. What is that temperature in Kelvin?

$$\frac{\left(-129 + 40\right)}{1.8} - 40 + 273.15 = 184K$$

Part 3: Percent: - way of expressing a fraction

Fraction = part/whole

Percent = fraction(100)

Note, the some of the parts = the whole
(sum of fractions = 1   sum of percents = 100)

What is the percent salt if 23.5 g of salt is mixed with 91 g water?

$$\%Salt = \left(\frac{m_{Salt}}{m_{Salt} + m_{Water}}\right)100 = \frac{23.5g}{23.5g + 91g}100$$

$$= \frac{23.5}{114.5}100 = .20524(100) = 20.5\%salt$$

What is the percent water if 23.5 g of salt is mixed with 91 g water?

$$\%Water = \left(\frac{m_{Water}}{m_{Salt} + m_{Water}}\right)100 = \frac{91g}{23.5g + 91g}100$$

$$= \frac{91}{114.5}100 = .79476(100) = 79\%salt$$

Note, there are two ways as we already know % salt, be BE CAREFUL of Sig Figs.
Whole - % salt = % water
100% - 20.5% = 79.5%
(exact) (meas)

This second way is considered wrong

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What mass of Water do you need to add to 55.4g of salt to make a solution that is 15.0% Salt?

$$\%salt = \frac{m_S}{m_S + m_W}(100)$$

$$Fraction\,salt = f_S = \frac{\%salt}{100}$$

$$f_S = \frac{m_S}{m_S + m_W}$$

$$f_S\left(m_S + m_W\right) = m_S$$

$$f_S m_S + f_S m_W = m_S$$

$$f_S m_W = m_S - f_S m_S = m_S(1 - f_S)$$

$$m_W = \frac{(1-f_S)}{f_S} m_S = \frac{(1-.150)}{.150} 55.4g = \frac{.850}{.150} 55.4g = 314g$$

Note, the last eq could have been written as

$m_W = \frac{f_w}{f_S} m_S$ which can be rearranged to $\frac{m_w}{m_S} = \frac{f_w}{f_S}$

Problems:

1. What is the mass of water in a solution which is 34.5% water and has 23.6g salt?

$$f_S = \frac{m_S}{m_S + m_W}$$

$$f_S\left(m_S + m_W\right) = m_S$$

$$f_S m_S + f_S m_W = m_S$$

$$f_S m_W = m_S - f_S m_S = m_S(1 - f_S)$$

$$m_W = \frac{(1-f_S)}{f_S} m_S = \frac{f_w}{f_S} m_S = \frac{.345}{.655} 23.6g = 12.4g$$

2. What is the mass of water in a solution which is 34.5% salt and has 23.6g salt?

$$f_S = \frac{m_S}{m_S + m_W}$$
$$f_S\left(m_S + m_W\right) = m_S$$
$$f_S m_S + f_S m_W = m_S$$
$$f_S m_W = m_S - f_S m_S = m_S(1 - f_S)$$
$$m_W = \frac{(1 - f_S)}{f_S} m_S = \frac{(1 - .345)}{.345} 23.6g = 44.8g$$

3. What is the mass of salt in a solution which is 34.5% water and has 23.6g water?

$$\frac{f_w}{f_S} = \frac{m_w}{m_s}$$
$$m_s = m_w \frac{f_s}{f_w} = 23.6\left(\frac{.655}{.345}\right) = 44.6g$$

4. What is the mass of salt in a solution which is 34.5% salt and has 23.6g water?

$$\frac{f_w}{f_S} = \frac{m_w}{m_s}$$
$$m_s = m_w \frac{f_s}{f_w} = 23.6\left(\frac{.345}{.655}\right) = 12.4g$$