1 MEASUREMENTS AND CALCULATIONS

Tw SUd-0.002e 0.008 Tc0 Tw[(2)(23)(0)(1)(1)]TJ F1 1

$m \cdot s^{-1}$). Write the speed of light in standard scientific notation.

____________________ speed of light in standard scientific notation

Implicit location of the decimal

The decimal will be moved to the **left** by 8 places, therefore the factor is 10^{+8}.

Thus

= x 100000000 = x 10^{+8}

8 zeroes

Applying the same principle to Avogadro's Number:

602 200 000 000 000 000 000 000 = 6.022 10^{+23}

23 places to the left

For small numbers (i.e., numbers less than 1), note that

= — =

= — x — =

= — x — x — =

=

For small numbers, movement of the decimal place is to the right.

e.g. Write the number 0.1234 in standard scientific notation.

$$0.1234 = 1.234 \times \frac{1}{10} = 1.234 \ 10^{\ 1}$$

e.g. Write the number 0.000314159 in standard scientific notation.

0.000314159 = 3.14159 times some power of 10

We need to move the decimal place 4 positions to the right (this will result in a negative exponent)

Therefore 0.000314159 = 3.14159 10^{-4}

1.1.1 Operations Using Powers of 10

1.1.1.4 Raising a power of ten to another power: multiply the exponents.

1.1.1.5 Fractional powers of ten: can be expressed as a root ( ).

$10^{1/2} \times 10^{1/2}$	$= 10^{1}$	Therefore	$10^{1/2} = \sqrt{}$

$10^{1/3} \times 10^{1/3}$

10

Exercise 1.1

$\sqrt{\quad} = \sqrt{\quad}$

These prefixes are used as a fast way of expressing the power of 10 to which a number is expressed.

Observe the use of prefixes, abbreviations, symbols and powers of ten:

One centimetre is one hundredth of a metre	1 cm = —— m = 10^{-2} m
One megawatt is a million watts	1 MW = 10^{6} W,
One kilohertz is a thousand hertz	1 kHz = 10^{3} Hz.

For each unit below, write the abbreviation, the power of ten and the basic unit if it is not already written:

1. one milligram = g
2. one microsecond = = s
3. one kilocal = = cal
4. one nanocoulomb = = C
5. one gigawatt = = W

CONVERTING FROM ONE UNIT SCALE TO ANOTHER

Step 2: A conversion factor (CF) is needed to relate the two sets of units. First examine the

1.3 Significant Figures

In science there are two methods of acquiring numbers. One method is by counting; the other is by measurement. Counting is by its very nature exact. Measurement on the other hand is done by comparison with a calibrated instrument. Since there are limitations on the scales of all calibrated instruments, there is a limit to the accuracy to which any measurement may be made. The use of significant figures expresses the extent of this accuracy. The use of significant figures is really only an approximate method for handling uncertainty in measurement and its propagation. For a more complete and formal treatment of error, see the section on Percentage Error and Percentage Difference in the following section on Error Analysis.

1.3.1 DETERMINING THE NUMBER OF SIGNIFICANT FIGURES

1.3.1.1 Non-zero Digits

All non-zero digits in a number are significant.

1.3.1.2 Zeroes

There are three classes of zeroes to be considered

a) **Leading Zeroes**

1.3.2.2 Addition and Subtraction

Exercises 1.3

1. How many significant digits are present in the following numbers?

   102

   000 000 034 89

   2500

   0.000 3004

   0.00 520700

2. Round off the following numbers to 3 significant figures.

   435

   76145

   22752

   9997

   2500

   46459

3. Perform the following calculations

   149.2+ 0.034 + 2000.34

   $1.0322 \times 10^{3} + 4.34 \times 10^{3}$

   $4.03 \times 10^{-2} - 2.44 \times 10^{-3}$

   $2.094 \times 10^{5} - 1.073 \times 10^{6}$

   $(0.0432)(2.909)(4.43 \times 10^{8})$

   (2.9932 x 10

1.4 Error Analysis

All measurements involve an element of uncertainty. In experiments, therefore, it will be important to determine quantitatively how these uncertainties affect the values that are computed from the data. There are two aspects of error analysis. The first involves the comparison of a measured value with an accepted or literature value. The second involves an analysis of the uncertainty in the actual measurement. Consequently there will be an uncertainty in any final result based on this measurement. This uncertainty exists whether or not an accepted value is known.

Comparison with a Literature Value: If a generally accepted value of a quantity, Y, is known to exist

1.5 Dimensional Analysis

Dimensional analysis is a problem solving technique based on an analysis of units. It is used to solve two types of problems:

1. Converting from one system of units to another; and
2. Relating one physical quantity to another using a definition.

Dimensional analysis has already been used to convert between different powers, e.g., from µm to nm. The technique is always the same: find a conversion factor that relates one unit to another or one physical quantity to another. Finding the appropriate conversion factor may not be a simple process – at times, several related conversion factors must be linked to obtain the desired conversion factor.

Example 1: How many ounces are in 24.3 pounds?

Note that this is a conversion of one unit of mass (ounces) to another (pounds).

Step 1: Write the given datum on the left hand side of a proposed inequality. On the right hand side, write the required unit.

1.5.1 CONVERTING UNITS : AREA

Shape	Name	Formula
	Rectangle	bh
	Square	s^2
	Parallelogram	bh
	Triangle	$½bh$
rr	Circle	

1.5.3 CONVERTING UNITS: DENSITY

Density is an intrinsic property of a pure substance. It relates the mass of the substance to its volume at a given temperature and pressure.

The formula for density can be manipulated according to the requirements of the problem.

<u>Example 1a)</u>

You want to built a raft from a new material which, according to the manufacturer, has a density of 4.56 g/cm^3. Will this raft float? Note that for the raft to float, its density should be less than that of water: 1.00×10^3 kg/m^3.

To compare 4.56 g/cm^3 with 1.00×10^3 kg/m^3 we have to convert some of the units. Among the various possibilities, let us choose the conversion: g kg and cm^3 m^3.

Therefore the density of the revolutionary material is significantly higher than that of water and, unless we trap in some air pockets or use other tricks, the raft will sink.

<u>Example 1b)</u>

What will be the total mass of the raft if it is 1.25 m wide, 1.95 m long and 6.50 cm high?

With the data given, we can easily calculate the volume of the raft:

$$Volume = 1.25\ m \times 1.95\ m \times .0650\ m = 0.158\ m^3$$

Now that we know the volume (0.158 m^3) and the density (4.56×10^3 kg/m^3) how can we calculate the mass?

Since: then: $mass = density \times volume$

Therefore, the raft has a mass of 0.158 $m^3 \times 4.56 \times 10^3$ kg/m^3 = e 7 1 Tf9.69423.293V.6942 346.68 m

It is observed from the data, that a change of 180°F corresponds to a change of 100°C but also that the zero point is 0°C whereas it is 32°F. Thus:

$$T_{°F} = \frac{\quad °F}{\quad °C} T_{°C} + \quad °F$$

For the conversion between Celsius and Kelvin, observe that the 100°C range between the fixed points of water also corresponds to a 100 K range. Thus the magnitude of 1°C equals 1 K. However, the zero point in the Kelvin scale begins at 273.15 K. Thus

$$T_K = T_{°C} + \qquad K$$

<u>Exercise 1</u>: What is the Fahrenheit temperature that corresponds to 80.0°C?

$$\begin{aligned} T_{°C} &= \quad °F \\ T_{°F} &= \quad T_{°C} + \quad °F \\ T_{°F} &= \qquad °F \; + \quad °F = \quad °F \end{aligned}$$

<u>Exercise 2</u>: What is the Celsius temperature that corresponds to 75.0°F?

$$\begin{aligned} T_{°F} &= \quad °F \\ T_{°F} &= \quad T_{°C} + \quad °F \\ T_{°C} &= \frac{T_{°F} \qquad °F}{\qquad} = \frac{\qquad}{\qquad} = \quad °C \end{aligned}$$

<u>Exercise 3</u>: At what value are the Celsius temperature and Fahrenheit temperatures equal?

$$\begin{aligned} T_{°F} &= T_{°C} \\ T_{°F} &= \quad T_{°C} + \quad °F \\ T_{°F} &= \quad T_{°F} + \quad °F \\ T_{°F} &= \quad °F \\ T_{°F} &= \frac{\quad °F}{\qquad} = \quad °F \end{aligned}$$

<u>Exercise 4</u>: What is the absolute (Kelvin) temperature that corresponds to 92.0°C?

$$\begin{aligned} T_{°C} &= \quad °C \\ T_K &= \quad + \\ T_K &= \end{aligned}$$

<u>Exercise 5</u>: What is the Celsius temperature that corresponds to 345 K?

$$\begin{aligned} T_K &= \quad K \\ T_{°C} &= \\ T_{°C} &= \quad °C \end{aligned}$$

<u>Exercise 5:</u> What is the absolute (Kelvin) temperature that corresponds to 100°F?

$$\begin{aligned} &T_{°F} \qquad F \\ &T_{°C} \quad \frac{T_{°F} \qquad}{\qquad} \quad \frac{\qquad}{\qquad} \qquad C \\ &T_K \qquad\qquad\qquad K \end{aligned}$$