Chemistry for Allied Health
An OpenTextbook

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CHEMISTRY FOR ALLIED HEALTH: AN OPENTEXTBOOK 3


## Measurements

MMEASURING is an important part of our everyday lives, and probably you took some measurements today. You might have drunk a cup of coffee in the morning, or checked the outside temperature in a thermometer. Perhaps you baked a cake following a recipe and measured the mass of flour and sugar using a scale. A cup, a thermometer or a scale are measuring devices.This chapter will cover how to accurately measure properties and convert units. You will for example learn how to convert milliliters to cubic centimeters, or how to compute the density of a substance. By learning how to measure, you will gain experience performing chemistry calculations.

### 1.1 Units of Measurements

You probably heard the term liter, kilogram or meter. These are units of measurement. Units can be classified in different metric systems. In particular here we will address two: the Metric System and the International System. The Metric System (MS) is used by health professionals throughout the world and the most common measuring system. The International System of Units (SI) was adopted by scientists to provide additional uniformity for units used in science. In the following we will introduce some common metric and international units .

Length What is your height? Length refers to space and both the metric and SI unit of length is the meter $(\mathrm{m})$. A smaller unit of length would be the centimeter $(\mathrm{cm})$ that is commonly used in chemistry. The most important units of lenghth are: meter, inch and mile.

Vol ume How much milk do you usually buy? Maybe a gallon. Volume is the amount of space that a substance occupies. A liter ( L ) is commonly used to measure volume. The milliliter ( mL ) is more convenient for measuring smaller volumes of fluids in hospitals and laboratories. Gallon is still used in every-day life. L, mL and gallon are units of volume.

Mass How much do you weight? The mass of an object is a measure of the quantity of material it contains. You may be more familiar with the term weight than with mass. However, mass and weight are not exactly the same, as weight is a measure of the gravitational pull on an object. It differs depending on the planet you live in. In the metric system, the unit for mass is the gram (g). The SI unit of mass, the kilogram (kg), is used for larger masses such as body weight. Pound, lb, is another unit of mass. The


Figure 1.1: The mass of an object can be measured with a scale


Figure 1.2: Time is measured with a watch

路Discussion: why is chemistry important for your career objective? List three reasons why chemistry connects with your career objective.

Table 1.1: The metric and international system (SI) units
most important units of mass are: $\mathrm{g}, \mathrm{kg}$ and lb .
Temperature How is the weather in NYC today? Is it cold or hot?You use a thermometer to see how hot something is, or how cold it is outside, or perhaps to determine if you have a fever. The temperature tells us how hot or cold an object is. Temperature can be measured in Celsius $\left({ }^{\circ} \mathrm{C}\right)$, Fahrenheit $\left({ }^{\circ} \mathrm{F}\right)$, or kelvins $(\mathrm{K})$. The three units of temperature are: ${ }^{\circ} \mathrm{C},{ }^{\circ} \mathrm{F}$ and K .

Time How long is your commute to work? It might take you hours or maybe minutes. You probably think of time as years, days, minutes, or seconds. Of these, the SI and metric basic unit of time is the second ( s ). time can be measured in: s , min, or h .

## Sample Problem 1

State the type of measurement indicated in each of the following:
(a) 1 dm
(b) 20 Kg
(c) 3 L
(d) 300 K

## SOLUTION

(a) length; (b) weight or mass; (c) volume; (d) Temperature;

* STUDY CHECK

State the type of measurement indicated in each of the following:
(a) 800 F
(b) 3 cL
(c) 3 cm

Answer: (a) Temperature; (b) volume; (c) length;

| Measuremts | Metric System | International System (SI) |
| :--- | :--- | :--- |
| Length | Meter $(\mathrm{m})$ | Meter $(\mathrm{m})$ |
| Volume | Liter $(\mathrm{L})$ | Cubic meter $\left(m^{3}\right)$ |
| Mass | Gram $(\mathrm{g})$ | Kilogram $(\mathrm{kg})$ |
| Time | Second $(\mathrm{s})$ | Second $(\mathrm{s})$ |
| Temperature | Celsius $\left({ }^{\circ} \mathrm{C}\right)$ | Kelvin $(\mathrm{K})$ |

### 1.2 Prefixes \& Conversion Factors

Let's consider: $\mathbf{k m}, \mathbf{c m}, \mathrm{m}$, which can be read as centimeter, kilometer and meter. The word kilo (k) and centi (c) are called prefixed whereas meter (m) is the unit. Kilometer is larger than meter, whereas centimeter is smaller than a meter. A prefix such as kilo or centi can be attached to any unit to increase or decrease its size. Hence we can talk about a centimeter ( $\mathbf{c m}$ ) but also about a centisecond (cs) or centiliter (cL). The following table lists some of the metric prefixes, their symbols, and their decimal values.

How to identify the prefix? Look for example in cm . Centi (c) is the prefix and means $1 \times 10^{-2}$ and meter $(\mathrm{m})$ is the unit which refers to lenth. Another example, kg means kilogram. Kilo $(\mathrm{k})$ is the prefix and means $1 \times 10^{3}$, whereas gram $(\mathrm{g})$ is the unit that refers to mass. The prefix refers to the first letter whereas the unit refers to the last letter.

Table 1.2: Table containing some Prefixes. For example, 1 km is a thousand $\left(1 \times 10^{3}\right)$ meters, and 1 ms is $\left(1 \times 10^{-3}\right)$ seconds. The prefixes on top of the table are larger than the unit, and for examples 1Tbite is larger than a bite. The prefixed on the bottom are smaller than the unit, and 1 fs is smaller than a second.

| Prefix | Symbol | Value |
| :--- | :--- | :--- |
| tera | T | $1 \times 10^{12}$ |
| giga | G | $1 \times 10^{9}$ |
| mega | M | $1 \times 10^{6}$ |
| kilo | k | $1 \times 10^{3}$ |
| deci | d | $1 \times 10^{-1}$ |
| centi | c | $1 \times 10^{-2}$ |
| milli | m | $1 \times 10^{-3}$ |
| micro | $\mu$ | $1 \times 10^{-6}$ |
| nano | n | $1 \times 10^{-9}$ |
| pico | p | $1 \times 10^{-12}$ |
| femto | f | $1 \times 10^{-15}$ |

What would you prefer to own a kilodollar, a dollar or a centidollar? A unit with a prefix can be bigger or smaller than the plain unit-this is the unit without prefix-, depending on the prefix. The following prefixes make the unit smaller: deci, centi, milli, micro, nano, pico and femto. For example a fs (fentosecond) is smaller than a s (second). Differently, the following prefixes make the unit larger: Tera, Giga, Mega. For example a Tb (terabite) is larger than ab (bite). Bite is a unit used in computer science.

How to write unit equalities? Unit equalities are simple expressions that relates a unit with a unit with prefix. For example: one centimeter (cm) is $1 \times 10^{-2} \mathrm{~m}$. Hence we can write this as a unit equality:

$$
1 \mathrm{~cm}=1 \times 10^{-2} \mathrm{~m} \text { unit equality }
$$

How to write conversion factors? Let's compare cm and m . The first, cm , is a unit with a prefix, whereas $m$ is simple a unit of length without a prefix. In order know how many $m$ are there in a cm we need to write down a conversion factor. Think in the prefixes as synonymous of a number. In this way, centi stands for $1 \times 10^{-2}$, so

$$
\frac{1 \mathrm{~cm}}{1 \times 10^{-2} \mathrm{~m}} \text { or } \frac{1 \times 10^{-2} \mathrm{~m}}{1 \mathrm{~cm}} \text { conversion factor }
$$

| Unit | Equality |
| :--- | :--- |
| Inches (in)-centimeters (cm) | $2.54 \mathrm{~cm}=1 \mathrm{in}$ |
| minutes (min)-hours (h) | $60 \mathrm{~min}=1 \mathrm{~h}$ |
| minutes (min)-seconds (s) | $60 \mathrm{~s}=1 \mathrm{~min}$ |
| pound (lb)-grams (g) | $454 \mathrm{~g}=1 \mathrm{lb}$ |
| cubic centimeter $\left(\mathrm{cm}^{3}\right)$-mililiters (mL) | $1 \mathrm{~mL}=1 \mathrm{~cm}^{3}$ |
| Liter (L)-cubic decimeters $\left(d \mathrm{~m}^{3}\right)$ | $1 \mathrm{~L}=1 \mathrm{~m}^{3}$ |
| drops-mililiters (mL) | $1 \mathrm{~mL}=15$ drops |

( $چ 0$ Remember: the prefix always comes first as in $\mathbf{c}$

Q才 Remember: equalities are written in line whereas conversion factors with a fraction.


Table 1.3: Table containing some common unit equalities.


Figure 1.3: The different scales of the matter


Figure 1.4: How many mL do you add to your eye?

## Sample Problem 2

Complete each of the following equalities and conversion factors:
(a) $1 \mathrm{dm}=$ $\qquad$ m
(c) $\frac{1 \mathrm{~nm}}{m}$
(b) $1 \mathrm{~km}=$ $\qquad$
(d) $\frac{m}{1 \mathrm{~cm}}$

## SOLUTION

(a) $1 \mathrm{dm}=1 \times 10^{-1} \mathrm{~m}$; (b) $1 \mathrm{~km}=1 \times 10^{3} \mathrm{~m}$; (c) $\frac{1 \mathrm{~nm}}{1 \times 10^{-9} \mathrm{~m}}$; (d) $\frac{1 \times 10^{-2} \mathrm{~m}}{1 \mathrm{~cm}}$;
© STUDY CHECK

## * STUDY CHECK

Second is a unit of time. Complete each of the following equalities and conversion factors involving seconds:
(a) $1 \mathrm{cs}=$ $\qquad$ s
(b)

(c) $\frac{s}{1 M s}$
Answer: (a) $1 \mathrm{cs}=1 \times 10^{-2} s$; (b) $\frac{1 \times 10^{12} s}{1 T s}$; (c) $\frac{1 \times 10^{6} s}{1 M s}$;

Unit equalities in the form of conversion factors are used to convert a unit into another Sometimes one wants to get rid of a prefix, such as when we transform centimeter (cm) into meter (m). Sometimes, one wants to convert a prefix into another. An example would be converting centimeters $(\mathrm{cm})$ to millimeters (mm). Let's work on some example.

Removing or adding prefixes Imagine that you need to remove a prefix from a unit, and convert 3 km in meters. First, you would need the conversion factor corresponding to the prefix (centi) from Table ??. Then you need to arrange the conversion factor placing the prefix in the bottom of the fraction. This will cancel out the prefix from the number and the conversion factor leaving the plain unit on top of the conversion factor (the final unit). The arrangement would be:

$$
3 \operatorname{km} \times \frac{1 \times 10^{3} \mathrm{~m}}{1 \mathrm{~cm}}=3000 \mathrm{~m}
$$

Imagine now that you need to add a prefix into a unit, and convert 4000 m in km . The same would apply for this case, but now you will have to arrange the conversion factor so that the prefix is on the top:

$$
4000 \not \swarrow K \times \frac{1 \mathrm{~km}}{1 \times 10^{3} \not \swarrow}=4 \mathrm{~km}
$$

## Sample Problem 3

The length of a textbook page is 20 cm . Convert 20 cm to m .

## SOLUTION

In order to convert 20 cm into meters, we need to remove the prefix (centi) leaving the unit (meter) without any prefix. We will use the conversion factor that relates m to $\mathrm{cm}: \frac{1 \times 10^{-2} \mathrm{~m}}{1 \mathrm{~cm}}$ or $\frac{1 \mathrm{~cm}}{1 \times 10^{-2} \mathrm{~m}}$. We will arrange the conversion factor so that cm cancels giving m and hence we will use $\frac{1 \times 10^{-2} \mathrm{~m}}{1 \mathrm{~cm}}$ :

$$
20 \mathrm{~cm} \times \frac{1 \times 10^{-2} m}{1 \mathrm{~cm}}=0.2 m
$$

The units on top and on the bottom of the formula cancel and we get meters.

## * STUDY CHECK

Convert 100 m to km .

$$
\text { Answer: } 100 \not \Longrightarrow \pi \times \frac{1 \times 10^{3} \mathrm{~m}}{1 \mathrm{kom}}=100000 \mathrm{~m} \text {. }
$$

Switching prefixes In order to switch a prefix into another prefix, such as transforming 30 millimeters ( 30 mm ) into centimeters ( cm ), you will need two conversion factors: the first corresponds to the prefix to be removed (milli), whereas the second conversion factor corresponds to the prefix to be introduced (centi). You will get the conversion factors from Table 1.2. You will arrange the first conversion factor so that the prefix to be removes cancels from top to bottom and the second conversion factor so that on the top part of the conversion factor you have the prefix to be introduced. For this example:

$$
30 \mathrm{~mm} \times \frac{1 \times 10^{-3} \mathrm{~m}}{1 \mathrm{~mm}} \times \frac{1 \mathrm{~cm}}{1 \times 10^{-2} \mathrm{~m}}=3 \mathrm{~cm}
$$



Figure 1.5: Rulers normally have the cm and inch conversion written.


Figure 1.6: The per-feet-square price in Tribeca where The Borough of Manhattan Community College is located in NYC is \$1, 750

## Sample Problem 4

The length of a textbook page is 20 cm . How many mm is this lenth.

## SOLUTION

We want to convert 20 cm into mm , that is, we are switching prefixed. In order to do this, you need two conversion factors: $\frac{1 \times 10^{-2} m}{1 \mathrm{~cm}}$ and $\frac{1 \times 10^{-3} \mathrm{~m}}{1 \mathrm{~mm}}$. You will have to arrange the number $(20 \mathrm{~cm})$ and the two conversion factors in the following form:

$$
20 \mathrm{~cm} \times \frac{1 \times 10^{-2} \mathrm{~m}}{1 \mathrm{~cm}} \times \frac{1 \mathrm{~mm}}{1 \times 10^{-3} \mathrm{~m}}=2 \mathrm{~mm}
$$

## STUDY CHECK

Convert 100 mm to km .

$$
\text { Answer:100man } \times \frac{1 \times 10^{-3} \mathrm{~m}}{11 \mathrm{~mm}} \times \frac{1 \mathrm{~km}}{1 \times 10^{3} \mathrm{~m}}=1 \times 10^{-4} \mathrm{~km}
$$

Using other equalities How many hours is 300 minutes, or how many centimeters is 2 inched? Some of the units conversion are not based on a power of ten relationship such as the ones in Table 1.2. Table 1.3 lists some of the common equalities that can be easily converted into conversion factor. As an example, the unit equivalency between hours and minutes is $60 \mathrm{~min}=1 \mathrm{~h}$ and the conversion factor would be $\frac{60 \mathrm{~min}}{1 h}$ or $\frac{1 h}{60 \min }$.

## Sample Problem 5

Convert 20 in to cm .

## SOLUTION

We want to convert 20 inches into centimeters. Inch is not in Table 1.2 but in 1.3. In order to do this, you need the conversion factor: $\frac{1 \mathrm{in}}{2.54 \mathrm{~cm}}$ or $\frac{2.54 \mathrm{~cm}}{1 \mathrm{in}}$. You will have to arrange the number ( 20 in ) and the conversion factor in the following form:

$$
20 j \hbar \times \frac{2.54 \mathrm{~cm}}{1 j \hbar}=50.80 \mathrm{~cm}
$$

STUDY CHECK Convert 200 mL to drops.
Answer: $200 m L \times \frac{15 d r o p s}{1 m L}=3000$ drops $=3 \times 10^{3}$ drops

Square or cubic units How big is your apartment? You might be living in a $750 \mathrm{ft}^{2}$ loft in Brooklyn or in a larger house Upstate. Often times we encounter cubic or square units such as cubic centimeter $\left(\mathrm{cm}^{3}\right)$ or square feet $\left(f t^{2}\right)$. The equivalencies for cubic or square units should take into account the unit power (power of two or power of three). If $1 \mathrm{~cm}=1 \times 10^{-2} \mathrm{~m}$, for square units the relation should be squared and $1 \mathrm{~cm}^{2}=1 \times\left(10^{-2}\right)^{2} \mathrm{~m}^{2}=1 \times 10^{-4} \mathrm{~m}^{2}$. Similarly, if $1 \mathrm{~mm}=1 \times 10^{-3} \mathrm{~m}$, hence $1 \mathrm{~mm}^{3}=1 \times\left(10^{-3}\right)^{3} \mathrm{~m}^{3}=1 \times 10^{-9} \mathrm{~m}^{3}$.

Remember: is you use a power on a power of ten, the power and the ten exponent multiplies, and for example $1 \times\left(10^{-2}\right)^{2}$ is $1 \times 10^{-4}$ or $1 \times\left(10^{-4}\right)^{3}$ is $1 \times 10^{-12}$. Also the power key in your calculator is $\wedge^{\wedge}$

## Sample Problem 6

How many $\mathrm{m}^{2}$ is $20 \mathrm{~cm}^{2}$.

## SOLUTION

In order to convert $20 \mathrm{~cm}^{2}$ to square meters, we need to remove the centi prefix and that will give us the unit square meter without any prefix. We will use the conversion factor that relates $\mathrm{m}^{2}$ to $\mathrm{cm}^{2}: \frac{1 \times 10^{-4} \mathrm{~m}^{2}}{1 \mathrm{~cm}^{2}}$ or $\frac{1 \mathrm{~cm}^{2}}{1 \times 10^{-4} \mathrm{~m}^{2}}$.

$$
20 c n^{2} \times \frac{1 \times 10^{-4} m^{2}}{1 c n^{2}}=2 \times 10^{-3} m^{2}
$$

## * STUDY CHECK

Convert $100 m^{3}$ to $d m^{3}$.

$$
\text { Answer: } 100 m^{3} \times \frac{1 d m^{3}}{1 \times 10^{-3} m^{3}}=1 \times 10^{5} \mathrm{dm}^{3}
$$

### 1.4 Significant Figures

Numbers that results from the measurement of an experimental property are subject to uncertainty. Think about how many eggs are there in your refrigerator, there might be three and this number is an exact and certain number. Differently if you weight a single egg in an scale depending of the type of scale you used you will measure 70 g or 71 g or maybe 70.8 g . The mass of an egg is a measured property and hence some of the digits of the measurement are uncertain. The goal of this section is, given a value, calculate the number of significant figures of digits (we will refer to significant figures as SF). In general all numbers different than zero are significant and for example the number 123 has three significant figures. Similarly, the number 45 has two significant figures. Zeros are also significant except when:

Exception 1 A zero is not significant if it is at the beginning of a decimal number. For example, the number 0.123 has three significant figure, as the first zero is not significant. Similarly, the number 0.002340 has four significant figures as the first three zeros are not significant but the last zero it is. Mind the rule affects only the zeros at the beginning.

Exception 2 A zero is not significant if it is used as a placeholder in a large number without a decimal point. . For example, the number 1000 has only one significant figure, and the number 3400 has two.
Let us consider more examples. The number 120 has two significant figures, as according to the second rule the last zero is not significant. Differently, the number 1203 has four significant figures, as the zero in between two numbers is not affected by neither the first nor the second rule

## Sample Problem 7

Indicate the number of significant figures in the following numbers: 123,4567 , $1200,340,0.001,0.023$ and 0.0405 .

## SOLUTION



Figure 1.7: Ice floats on water as the density of ice is lower than $1 \frac{g}{m L}$

123 has three significant figures, whereas 4567 has four SF. 1200 has only 2SF as the last two zeros are not significant, and 340 has only 2 SF as the last zero is not significant. 0.001 has only one significant figure as the first 3 zeros are not significant and 0.023 has only two SFs. Finally, 0.0405 has threee SFs as the first two zeros are not significant but the zero between 4 and 5 is indeed significant.

## * STUDY CHECK

Indicate the number of significant figures (SFs) in the following numbers: 4560, $0.123,1000$ and 0.0030 .

Answer: 4560 has 3SF, 0.123 has 3SF, 1000 has 1 SF and 0.0030 has 2SF.

### 1.5 Density

Density refers to the mass of a substance with respect to its volume. This is an unique property for each substance. For example, the density for copper is $8.92 \mathrm{~g} \cdot \mathrm{ml}^{-1}$ and for gold is $19.3 g \cdot m l^{-1}$. By measuring density only you would be able to differentiate copper than gold. The larger density the more compact is an object and that means the more mass per volume it has. The formula for density is

$$
\begin{equation*}
\text { Density }=\frac{\text { Mass of substance }}{\text { Volume of substance }} \tag{1.1}
\end{equation*}
$$

Density and mixing Ice is solid and it floats on water. The reason for that is density: density of ice is smaller than density of water and hence ice stays on top of water. Objects with density larger than $1 \frac{g}{m L}$ will sink whereas objects with density smaller than $1 \frac{g}{m L}$ will float. If you add a drop of vegetable oil to a glass of water, the drop will float. This is because density of oil that is smaller than $1 \frac{g}{m L}$.

## Sample Problem 8

In the figure we mixed three liquids of density: $\mathrm{A}\left(0.5 \frac{g}{m L}\right), \mathrm{B}\left(2 \frac{g}{m L}\right)$ and $\mathrm{C}\left(1 \frac{g}{m L}\right)$. Identify each liquid.


## SOLUTION

The heavier the liquid, that is the larger density, the lower the liquid will arrange in the mixture. From top to bottom we have A, C and B.

## Sample Problem 9

After adding a 30 g object into a cylinder filled of water, the level of water rises from 60 mL to 90 mL . Calculate the density of the object.


## SOLUTION

Density is mass over volume. The mass of the object is 30 g and its volume is
$(90-60) \mathrm{mL}$ that is 30 mL . Hence: $d=\frac{30 g}{30 m L}=1 \frac{g}{m L}$.

## - STUDY CHECK

A lead weight used in the belt of a scuba diver has a mass of 226 g . When the weight is placed in a graduated cylinder containing 200.0 mL of water, the water level rises to 220.0 mL . What is the density of the lead weight $\left(\frac{g}{m L}\right)$ ?

$$
\text { Answer: } d=\frac{226 g}{20 m L}=11.3 \frac{g}{m L}
$$

## CHAPTER 1

## UNITS AND MEASUREMENTS

1. A value of 30 min is a measure of
(a) length
(d) time
(b) volume
(c) mass
(e) temperature
2. A value of 2 L is a measure of
(a) length
(d) time
(b) volume
(c) mass
(e) temperature

Ans: (d)
9.

1 $1 d m=$ $\qquad$ m
(a) $1 \times 10^{-1}$
(d) $1 \times 10^{-6}$
(b) $1 \times 10^{3}$
(c) $1 \times 10^{-2}$
(e) $1 \times 10^{12}$

Ans: (b)
3. A value of 5 cm is a measure of
(a) length
(d) time
(b) volume
(c) mass
(e) temperature

Ans: (a)
4. The metric base unit for volume is the
(a) $m^{3}$
(d) mL
(b) L
(c) $\mathrm{cm}^{3}$
(e) $m^{2}$

Ans: (b)
5. The metric base unit for mass is the
(a) g
(d) L
(b) Kg
(c) lb
(e) cm

Ans: (a)
6. Which of the following is the basic unit of mass in the SI?
(a) pound
(c) milligram
(b) kilogram
(d) microgram
8. The amount of space occupied by a substance is its
(a) mass
(d) length
(b) density
(c) weight
(e) volume

Ans: (e)

## Prefixes \& Conversion Factors

Fill the gap in the following unit equalities or conversion factors: m

Ans: (a)
10. Fill the gap in the following unit equalities or conversion factors: $1 \mathrm{~cm}=\mathrm{m}$
(a) $1 \times 10^{-1}$
(d) $1 \times 10^{-6}$
(b) $1 \times 10^{3}$
(c) $1 \times 10^{-2}$
(e) $1 \times 10^{12}$

Ans: (c)
11. Fill the gap in the following unit equalities or conversion factors: $\frac{1 \mathrm{~nm}}{m}$
(a) $1 \times 10^{-1}$
(d) $1 \times 10^{-6}$
(b) $1 \times 10^{-9}$
(c) $1 \times 10^{-2}$
(e) $1 \times 10^{12}$

Ans: (b)
12. Fill the gap in the following unit equalities or conversion factors: $\frac{1 \mathrm{fs}}{\mathrm{s}}$
(a) $1 \times 10^{-1}$
(d) $1 \times 10^{-15}$
(b) $1 \times 10^{-9}$
(c) $1 \times 10^{-2}$
(e) $1 \times 10^{-12}$

Ans: (e)
Ans: (b)
7. Which of the following is a measurement of mass in the metric system?
(a) milliliter
(d) Celsius
(b) centimeter
(c) gram
(e) meter

1
13. Fill the gap in the following conversion factors: $20 \operatorname{cm} \times$ $\frac{m}{1 \mathrm{~cm}}=0.2 m$
(a) $1 \times 10^{-2}$
(d) $1 \times 10^{3}$
(b) $1 \times 10^{-3}$
(c) $1 \times 10^{2}$
(e) $1 \times 10^{-6}$
14. Fill the gap in the following conversion factors: $20 \mathrm{~cm} \times$ $\frac{1 \times 10^{-2} \mathrm{~m}}{1 \mathrm{~cm}} \times \frac{1 \mathrm{~mm}}{1 \times 10^{-3} \mathrm{~m}}=$ $\qquad$ $m m$
(a) 200
(d) 0.2
(b) 2
(c) 2000
(e) 0.02

Ans: (a)
15. Fill the gap in the following conversion factors: $20 \mathrm{~cm} \times$ $\square=7.87 \mathrm{in}$
(a) $\frac{1 i n}{0 c m}$
(d) $\frac{2.54 i n}{1 \mathrm{~cm}}$
(b) $\frac{1 \mathrm{in}}{1 \mathrm{~cm}}$
(e) $\frac{1 i n}{2.54 c m}$
(c) $\frac{2.54 \mathrm{in}}{2.54 \mathrm{~cm}}$

Ans: (e)

## Significant Figures

16. Which of the following measurements has three significant figures?
(a) 0.005 m
(d) 0.051 m
(b) 510 m
(c) 0.510 m
(e) 5100 m

Ans: (c)
17. Which of the following numbers contains the designated CORRECT number of significant figures?
(a) 0.043005 SF
(d) 1.042 SF
(b) 0.003022 SF
(c) 1560003 SF
(e) 3.06504 SF

Ans: (c)
18. The number of significant figures in the measurement of 45.030 mm is
(a) None
(d) 5 SF
(b) 3 SF
(c) 4 SF
(e) 6SF

Ans: (d)

## Using Conversion Factors

19. The following conversion factor is used to convert $100 \mu \mathrm{~m}$ into $m$. Fill in the gaps:

$$
100 \mu m \times \frac{m}{1 \mu m}=1 \times 10^{-4} m
$$

Ans: $10 \cdot 10^{-6}$
20. The following conversion factor is used to convert 40 m into $n m$. Fill in the gaps:

$$
40 m \pi \times \frac{1 \mathrm{~nm}}{-m}=4 \times 10^{-8} n m
$$

21. The following conversion factor is used to convert 30 cm into km . Fill in the gaps:

$$
30 \mathrm{~cm} \times \frac{m}{1 \mathrm{~cm}} \times \frac{1 \mathrm{~km}}{m}=3 \times 10^{-4} \mathrm{~km}
$$

Ans: $10 \cdot 10^{-2} ; 10 \cdot 10^{3}$
22. The following conversion factor is used to convert 50 dm into cm . Fill in the gaps:


Ans: $10 \cdot 10^{-1} ; 10 \cdot 10^{-2}$
23. Set up the conversion factor to convert 500 cm into inches:


Ans: 19.68 in
24. Set up the conversion factor to convert $400 \mathrm{~cm}^{2}$ into $\mathrm{m}^{2}$ :

$$
400 \mathrm{sh}^{2} \times \square=\quad m^{2}
$$

Ans: $0.04 m^{2}$

## DENSITY

25. A nugget of gold with a mass of 521 g is added to 50.0 mL of water. The water level rises to a volume of 77.0 mL . What is the density of the gold?
(a) $10.4 \frac{\mathrm{~g}}{\mathrm{~mL}}$
(d) $23.68 \frac{g}{m L}$
(b) $6.77 \frac{\mathrm{~g}}{\mathrm{~mL}}$
(e) $19.3 \frac{\mathrm{~g}}{\mathrm{~mL}}$
(c) $1.00 \frac{g}{m L}$

Ans: (d)
26. Which one of the following substances will float in gasoline, which has a density of $0.66 \mathrm{~g} / \mathrm{mL}$ ?
(a) table salt $\left(2.16 \frac{g}{m L}\right)$
(b) balsa wood $\left(0.16 \frac{g}{m L}\right)$
(c) sugar $\left(1.59 \frac{g}{m L}\right)$
(d) aluminum $\left(2.70 \frac{g}{m L}\right)$
(e) mercury $\left(13.6 \frac{g}{m L}\right)$

Ans: (b)
27. Determine the density $(\mathrm{g} / \mathrm{mL})$ of a 0.01 L sample of a salt solution that has a mass of 50 g .

Ans: $5 g \cdot m l^{-1}$
28. A graduated cylinder contains 28.0 mL of water. What is the new water level after 35.6 g of silver metal is submerged in the water if the density of silver is $10 \mathrm{~g} / \mathrm{mL}$ ?

