Preparation for BioScience Academy
Math Entrance Test

Math is an essential component of laboratory science and solid math skills are required for a successful career in this field. To be eligible for BioScience Academy, applicants must therefore demonstrate mastery over basic science math and be able to solve simple word problems.

This review booklet covers the topics and types of problems that will appear on the math entrance test. Problem sets (with answer keys) are provided. Please note that this booklet is intended only as a review. If you have difficulties with some of the problems, you will need to seek more thorough explanations of the material online or in a textbook.

For the one hour entrance test, you will be given a metric conversion table identical to the one in this booklet. However, you will **not be allowed to use calculators**. You are therefore advised to do the math problems in this booklet without a calculator.

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CONVERTING BETWEEN PERCENT, FRACTIONS & DECIMALS

**PERCENT to FRACTION**
Remove % sign
Divide by 100

**PERCENT to DECIMAL**
Remove % sign
- a) multiply by 0.01 or
- b) divide by 100 or
- c) move decimal point 2 places to left

**FRACTION to PERCENT**
Multiply by 100
Add % sign

**DECIMAL to PERCENT**
Multiply by 100
Add % sign

**DECIMAL to FRACTION**
Count the number of decimal places.
Write the decimal number as a fraction over 1 followed by as many zeroes as there are decimal places.
Remove decimal point from original number. This is your fraction. Reduce to lowest terms.

**FRACTION to DECIMAL**
Divide numerator by denominator

---

**RULES FOR ROUNDING NUMBERS**
The standard method of rounding numbers is as follows;

If a digit to be dropped is less than 5, the preceding figure is not altered
   *Example: Round to one decimal place: 1.92 ⇒ 1.9*

If a digit to be dropped is more than 5, the preceding figure is increased by 1
   *Example: Round to one decimal place: 8.28 ⇒ 8.3*

If a digit to be dropped is 5, the preceding figure is increased by 1
   *Example: Round to one decimal place: 4.25 ⇒ 4.3*


**SOLVING ALGEBRAIC EQUATIONS**

Basic algebra is needed for formulas that are commonly used in the lab. The following examples review how to solve for an unknown value. There are only a few important rules to remember when solving algebraic equations. These are illustrated below:

**Example I**

\[z - 3 = 9\]
\[z - 3 (+3) = 9 (+3)\]
\[z - 0 = 12\]
\[z = 12\]

To solve for the unknown, we need to manipulate the equation so that the final equation reads \( z = \). To do this, we move all the expressions that are on the same side of the equal sign as \( z \) to the opposite side of the equation:

To move \(-3\) to the other side of the equation, we add its inverse \(+3\), and we do this to each side of the equation. Since \(-3 + 3\) equals zero, \( z \) is isolated.

*Why do we add \(+3\) to each side of the equation? Remember that the = sign means that the value of left hand side is equal to the value on the right. Whatever we do to one side of the equation, we need to do to the other side.*

**Example II**

\[4z = 24\]
\[4 \cdot \left(\frac{1}{4}\right) z = 24 \cdot \left(\frac{1}{4}\right)\]
\[1z = 6\]
\[z = 6\]

To solve for the unknown, we need to move \( 4 \) to the other side of the equation so that \( z \) is isolated.

To move \( 4 \), however, we cannot add or subtract it from \( z \) as we did in Example I. Instead, we need to multiply by the reciprocal of \( 4 \). Why?

\( 4z \) means “4 times \( z \).” When we multiply \( 4 \) by its reciprocal, we are left with \( 1z \), which is the same as \( z \). Remember that any number multiplied by its reciprocal gives 1:

\[4 \cdot \left(\frac{1}{4}\right) = 1\]
SCIENTIFIC NOTATION

Scientific notation is a shorthand way of writing very large (eg., 3,000,000,000,000) or very small numbers (eg., 0.0000000000000008).

Numbers written in scientific notation are composed of three parts: a coefficient, a base and an exponent.

The number 567,000,000,000 written in scientific notation is:

\[ 5.67 \times 10^{11} \]

The exponent can be either positive or negative and indicates how large or small a number is. A negative exponent indicates that a number is less than one; it does NOT mean the number is negative.

RULES FOR WRITING NUMBERS IN SCIENTIFIC NOTATION

Numbers written in scientific notation must meet the following criteria:

1. The **coefficient** must be greater than or equal to one, but less than ten.
   In other words: \[ 1 \leq \text{coefficient} < 10 \]

2. The **base** must be 10.

3. The **exponent** must indicate the number of decimal places that the decimal point needs to be moved to change the number to standard notation. (Standard notation is the usual way of writing numbers.)

CONVERTING BETWEEN SCIENTIFIC NOTATION AND STANDARD NOTATION

A) Steps for Converting from Standard Notation to Scientific Notation

a) Starting with the number in standard form, move the decimal point until the number is greater than or equal to one, but less than ten.

b) Multiply the number formed in step a) by 10 raised to the number of decimal places moved.
   i) If the original number in standard notation was less than 1, the exponent will be negative.
   ii) If the original number in standard notation was greater or equal to 1, the exponent will be positive.
Examples
Write each of the following numbers in scientific notation:  
(a) 93,000,000   
(b) 0.00005144

<table>
<thead>
<tr>
<th>Standard notation</th>
<th>Scientific Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 93,000,000</td>
<td>(9.3 \times 10^7)</td>
</tr>
</tbody>
</table>

i) If there is no decimal point in the number, then the decimal point is assumed to be at the end of the number. Move the decimal as many places as necessary to make the coefficient a number that is greater than or equal to one, but less than 10.

ii) Determine the sign of the exponent. Since 93,000,000 is greater than 1, the exponent will be positive. The decimal point was moved 7 places, so the exponent is 7.

<table>
<thead>
<tr>
<th>Standard notation</th>
<th>Scientific Notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>b) 0.00005144</td>
<td>(5.144 \times 10^{-5})</td>
</tr>
</tbody>
</table>

i) Move the decimal as many places as necessary to make the coefficient a number that is greater than or equal to one, but less than 10.

ii) Determine the sign of the exponent. Since 0.00005144 is less than 1, the exponent will be negative. The decimal point was moved 5 places, so the exponent is \(-5\).

B) Steps for Converting from Scientific Notation to Standard Notation

i) If the exponent is positive, this means that the number in standard notation will be greater than one. So move the decimal point to the right as many places as indicated by the exponent.

ii) If the exponent is negative, this means the number in standard notation will be less than one. So move the decimal point to the left as many places as indicated by the exponent.

Examples
Write each of the following in standard notation:  
a) \(3.45 \times 10^4\)   
b) \(6.73 \times 10^{-7}\)

<table>
<thead>
<tr>
<th>Scientific Notation</th>
<th>Standard notation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) (3.45 \times 10^4)</td>
<td>3.4500 (\Rightarrow) 34,500</td>
</tr>
</tbody>
</table>

The exponent is positive. Therefore, in standard notation, the number will greater than one. The exponent is 4, so move the decimal point 4 spaces. Add zeroes to the end of the number so that the decimal point can be moved as many places as needed.
Scientific Notation  
Standard notation  
b)  $6.73 \times 10^{-7} \Rightarrow 0000006.73 \Rightarrow 0.00000073$

The exponent is negative. Therefore, in standard notation, the number will less than one. The exponent is 7, so move the decimal point 7 spaces. Add zeroes in front of the number so that the decimal point can be moved as many places as needed. Always put a zero in front of the decimal point!!

**CALCULATIONS IN SCIENTIFIC NOTATION**

A) Steps for Multiplying Numbers in Scientific Notation

i) Multiply the coefficients.

ii) Add the exponents.

iii) Express the answer in scientific notation.

**Example**

\[(3.9 \times 10^{-5})(30.0 \times 10^{-2}) =\]

- multiply coefficients: $3.9 \times 30 = 117$
- $x 10^{-5} x 10^{-2} = 10^{-7}$ add exponents
- $117 \times 10^{-7}$
- express in scientific notation: $1.17 \times 10^{-2} \times 10^{-7} = 1.17 \times 10^{-5}$

B) Steps for Dividing Numbers in Scientific Notation

i) Divide the coefficients.

ii) Subtract the bottom exponent from the top exponent.

iii) Express the answer in scientific notation.

**Example**

\[
\frac{(180.0 \times 10^{-2})}{(0.3 \times 10^{9})}
\]

- Divide Coefficients: $\frac{180.0}{0.3} = 600.0$
- $\frac{x 10^{-2}}{10^{9}} = 10^{(-2-9)} = 10^{-11}$ Subtract bottom exponent from top exponent
- $600.0 \times 10^{-11}$
- Express in scientific notation: $6.0 \times 10^{7} \times 10^{-11} = 6.0 \times 10^{-9}$
To add numbers written in scientific notation, apply the principles of factoring and the distributive property.

\[ ab + ac = a(b + c) \]

(a is the common factor of both ab and ac, so it can be “factored out”)

\[
(4.2 \times 10^4) + (3.5 \times 10^4) = \]

\[
10^4(4.2 + 3.5) = \]

\[
10^4(7.7) = \]

\[
7.7 \times 10^4
\]

When the exponents are the same --as in the above problem-- addition and subtraction of numbers written in scientific notation is straightforward.

How do you solve a problem when the exponents are not the same? Answer: Re-write the problem so that the exponents are the same. It is okay to do this, provided that the values of the expressions in the original problem do not change:

**Example 1:**

\[
(2.0 \times 10^2) + (3.0 \times 10^3) = \]

*can be rewritten as:*

\[
(0.2 \times 10^1 \times 10^2) + (3.0 \times 10^3) = \]

\[
(0.2 \times 10^3) + (3.0 \times 10^3) = \]

\[
10^3(0.2 + 3.0) = \]

\[
10^3(3.2) = \]

\[
3.2 \times 10^3
\]

**Example 2:**

\[
(2.0 \times 10^7) - (6.3 \times 10^5) = \]

*can be rewritten as:*

\[
(200 \times 10^5) - (6.3 \times 10^5) = \]

\[
10^5(200 - 6.3) = \]

\[
10^5(193.7) = \]

\[
10^5(1.937 \times 10^2) = \]

\[
1.937 \times 10^7
\]
THE METRIC SYSTEM

The metric system is a decimal-based system of units for length, volume, weight and other measurements. Even though it is not widely used in everyday life here in the USA, the metric system is used in science; therefore, it is extremely important that you learn this system and the metric units of measurement that are commonly used in biomedical labs.

In the metric system, each type of measurement has a base unit. The base unit for length is meters (m), volume is liters (L) and mass/ weight is grams (g). For measurements that are tens of times smaller or larger than the base unit, prefixes are added to the base unit. Examples: the prefix *kilo-* indicates that the measurement is 1000 or $1 \times 10^3$ times larger than the base unit. The prefix *milli-* indicates that the measurement is $1 \times 10^{-3}$ or 0.001 times smaller than the base unit:

- 1 kilogram is $1000$ or $1 \times 10^3$ times the weight of 1 gram.
- 1 kilometer is $1000$ or $1 \times 10^3$ times the length of 1 meter.
- 1 milligram is 0.001 or $1 \times 10^{-3}$ times the weight of 1 gram.
- 1 millimeter is 0.001 or $1 \times 10^{-3}$ times the length of 1 meter.

The tables on the following two pages show the mathematical relationships between metric measurements. If you are not familiar with the metric system, this table might look very complex. However, through repeated use of the metric system in your laboratory classes, you will memorize many of the prefixes listed in the table and remember the relationship of each with the base unit.
## Metric System Relationships

A) Mathematical relationship between base units and other metric measurements.

<table>
<thead>
<tr>
<th>PREFIX</th>
<th>SYMBOL</th>
<th>MASS / WEIGHT</th>
<th>VOLUME</th>
<th>LENGTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>kilo-</td>
<td>k</td>
<td>1g = 1 x 10⁻³ kg</td>
<td>1L = 1 x 10⁻³ kl</td>
<td>1m = 1 x 10⁻³ km</td>
</tr>
<tr>
<td>centi-</td>
<td>c</td>
<td>centigram not commonly used in the lab</td>
<td>centiliter not commonly used in the lab</td>
<td>1cm = 1 x 10⁻² m</td>
</tr>
<tr>
<td>milli-</td>
<td>m</td>
<td>1g = 1 x 10⁻³ mg</td>
<td>1L = 1 x 10⁻³ ml</td>
<td>1m = 1 x 10⁻³ mm</td>
</tr>
<tr>
<td>micro-</td>
<td>µ</td>
<td>1g = 1 x 10⁻⁶ µg</td>
<td>1L = 1 x 10⁻⁶ µl</td>
<td>1m = 1 x 10⁻⁶ µm</td>
</tr>
<tr>
<td>nano-</td>
<td>n</td>
<td>1g = 1 x 10⁻⁹ ng</td>
<td>1L = 1 x 10⁻⁹ nl</td>
<td>1m = 1 x 10⁻⁹ nm</td>
</tr>
<tr>
<td>pico-</td>
<td>p</td>
<td>1g = 1 x 10⁻¹² pg</td>
<td>1L = 1 x 10⁻¹² pl</td>
<td>1m = 1 x 10⁻¹² pm</td>
</tr>
</tbody>
</table>
B) Mathematical relationships between metric measurements smaller than the base unit

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td></td>
</tr>
<tr>
<td>mm and µm</td>
<td>1mm = 1 x 10^3 µm</td>
</tr>
<tr>
<td>mm and nm</td>
<td>1mm = 1 x 10^6 nm</td>
</tr>
<tr>
<td>mm and pm</td>
<td>1mm = 1 x 10^9 pm</td>
</tr>
<tr>
<td>µm and nm</td>
<td>1µm = 1 x 10^3 nm</td>
</tr>
<tr>
<td>µm and pm</td>
<td>1µm = 1 x 10^6 pm</td>
</tr>
<tr>
<td>nm and pm</td>
<td>1nm = 1 x 10^3 pm</td>
</tr>
<tr>
<td><strong>Volume</strong></td>
<td></td>
</tr>
<tr>
<td>ml and µl</td>
<td>1ml = 1 x 10^3 µl</td>
</tr>
<tr>
<td>ml and nl</td>
<td>1ml = 1 x 10^6 nl</td>
</tr>
<tr>
<td>ml and pl</td>
<td>1ml = 1 x 10^9 pl</td>
</tr>
<tr>
<td>µl and nl</td>
<td>1µl = 1 x 10^3 nl</td>
</tr>
<tr>
<td>µl and pl</td>
<td>1µl = 1 x 10^6 pl</td>
</tr>
<tr>
<td>nl and pl</td>
<td>1nl = 1 x 10^3 pl</td>
</tr>
<tr>
<td><strong>Mass/Weight</strong></td>
<td></td>
</tr>
<tr>
<td>mg and µg</td>
<td>1mg = 1 x 10^3 µg</td>
</tr>
<tr>
<td>mg and ng</td>
<td>1mg = 1 x 10^6 ng</td>
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<td>1µg = 1 x 10^3 ng</td>
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<tr>
<td>µg and pg</td>
<td>1µg = 1 x 10^6 pg</td>
</tr>
<tr>
<td>ng and pg</td>
<td>1ng = 1 x 10^7 pg</td>
</tr>
</tbody>
</table>
METRIC CONVERSIONS

In your lab classes, you will use balances that weigh in grams and occasionally, balances that weigh in milligrams. You will also use various liquid measuring instruments including pipettes, which measure milliliter volumes, micropipettors that measure microliter volumes and graduated cylinders that can measure liter volumes. You will record all the measurements that you make in your lab notebook. However, you will frequently be required to convert your measurements from one unit to another. For example, you may weigh out 5 grams of a chemical, but then be told to report the weight in milligrams or, you may combine 300 microliters of one solution with 25 microliters of another solution, but be required to record the total volume in milliliters. Converting between metric units is not difficult, but requires a systematic approach such as that shown in the following:

CONVERSION FACTOR METHOD FOR SOLVING CONVERSION PROBLEMS

**EXAMPLE: 25 g is how many µg?**

1) Make sure you understand what is being asked:
   a) determine what units are involved
   \( g \) and \( µg \) in the example above
   b) determine what unit needs to be converted to what unit
   \( g \) needs to be converted to \( µg \) in the example above

2) Determine the relationship between the units in the problem:
   \( 1 \times 10^6 \, µg = 1 \, g \) in the example above

3) Write down the two conversion factors that are formed from the equation \( 1 \times 10^6 \, µg = 1 \, g \)
   \( \frac{1 \times 10^6 \, µg}{1 \, g} \) and \( \frac{1 \, g}{1 \times 10^6 \, µg} \)

4) Use one of the conversion factors to solve the problem: 25 g is how many \( µg \)?
   \[
   25 \, g \times \frac{1 \times 10^6 \, µg}{1 \, g} = \frac{25 \times 10^6 \, µg}{1 \, g} \\
   = 2.5 \times 10^7 \, µg \text{ (expressed in scientific notation)}
   \]

Select the conversion factor that has the unit you want to end up with on the top (in the numerator)
..."what you want, stays on top"

The grams and the 1's cancel out

PAY ATTENTION to the wording of conversion problems!
All of the following are asking for the same conversion:
How many \( µg \) is 25g?  Convert 25 g to \( µg \)  25 g is how many \( µg \)?  Express 25 g in \( µg \).
RATIOS AND PROPORTIONS

Review
A ratio is the amount of one measurement relative to another measurement. In other words, a ratio shows the relationship between two quantities.
Example: 1000 bacteria / 4 ml (in every 4 ml, there are 1000 bacteria)

Ratios can be written as fractions: \(rac{1000 \text{ bacteria}}{4 \text{ ml}}\)

Two ratios with different quantities can in fact represent the same relationship as shown in the example below. The number of bacteria and the volumes in each ratio differ, but the relationship between the values is the same.
\[
\frac{1000 \text{ bacteria}}{4 \text{ ml}} = \frac{250 \text{ bacteria}}{1 \text{ ml}}
\]

When two ratios describe the same relationship, they are said to be proportional. The term proportion refers to two equal ratios.

Lab Applications of Ratios and Proportions
Many lab math problems can be solved by applying the principles of ratios and proportions:

A) Ratio and proportion math is frequently used in solution preparation to calculate the amount of a substance or the volume of a liquid.

Example: A lab technician is about to conduct an experiment that requires a NaCl (sodium chloride) solution with a concentration of 8 mg/ml. However, 75 ml of the solution are needed for the experiment. How much NaCl is required for this volume?

To calculate how much NaCl is needed for 75 ml, set up a proportion:

\[
\frac{8 \text{ mg}}{1 \text{ ml}} = \frac{z}{75 \text{ ml}}
\]

Two methods can be used to solve for “z”.

i: Cross multiplication (make sure to include units in the process)

\[
8 \text{ mg} = z \quad z \times 1 \text{ ml} = 8 \text{ mg} \times 75 \text{ ml} \quad \Rightarrow \quad z = 600 \text{ mg}
\]

ii: Determine what the numerator or denominator of the first ratio needs to be multiplied or divided by to get the numerator or denominator in the second ratio.

\[
\frac{8 \text{ mg}}{1 \text{ ml}} = \frac{z}{75 \text{ mL}} \quad \frac{8 \text{ mg}}{1 \text{ ml}} \times 75 = 600 \text{ mg} \quad \Rightarrow \quad z = 600 \text{ mg}
\]

Therefore: the lab technician needs to dissolve 600 mg in a total volume of 75 ml.
B) Ratio and proportion math is used to compare the concentration of solutions.
   i) Cross multiplications shows that the following two solutions of NaCl do not have the same
   concentration:
   
   \[
   \begin{align*}
   &\text{Sol A} & &\text{Sol B} \\
   &8\text{g NaCl} & &250\text{g NaCl} \\
   &12\text{L} & &65\text{L}
   \end{align*}
   \]
   
   \[8\text{g} \times 65\text{L} \neq 250\text{g} \times 12\text{L}\]

   ii) By converting each concentration to g/L, it is possible to determine which solution is more
   concentrated:
   
   \[
   \begin{align*}
   &\text{Sol A} & &\text{Sol B} \\
   &8\text{g} & = 0.66\text{g} & &250\text{g} = 3.8\text{g} \\
   &12\text{L} & &65\text{L}
   \end{align*}
   \]
   
   \[\therefore \text{Sol B has the higher concentration}\]

C) Ratio and proportion math is used to convert concentrations as shown in B ii above. It is standard practice
   to express concentrations as an amount per 1 ml or an amount per 1 µl, etc.

   Example: A bottle of Protein X arrives in a lab with a specification sheet indicating that there are 0.5mg
   in a total volume of 4ml. The person receiving the bottle converts the concentration to mg/ml and
   labels the bottle accordingly:
   
   \[
   \frac{0.5\text{mg}}{4\text{ml}} = \frac{x}{1\text{ml}} \quad x = 0.125\text{mg} \quad \therefore \text{concentration of Protein X is 0.125mg/ml}
   \]

   Please note that per ml mean per 1 ml, but it is standard practice not to include the number 1.
   (This is similar to how a car’s mileage is expressed: 26 miles/ gallon is the same as 26 miles/ 1 gallon, but the 1
   is not included.)
PRACTICE PROBLEMS
You are encouraged to do all problems with and without the calculator since you will not be permitted to use a calculator on the entrance test. Answers for all worksheet problems can be found below the last worksheet.

CONVERTING BETWEEN FRACTIONS, DECIMALS AND PERCENTS Worksheet A

1) Convert from decimal to percent. 0.067 =

2) Convert from percent to decimal. 1.6% =

3) Convert from fraction to decimal. \frac{3}{600} =

4) Convert from decimal to fraction. 0.06 =

5) Convert from percent to fraction. 78% =

6) Convert from fraction to percent. \frac{5}{40} =

ROUNDING NUMBERS Worksheet B

Round the following numbers to one decimal place

1) 3.24 ⇒ 2) 5.298 ⇒ 3) 6.25 ⇒ 4) 0.56 ⇒

5) 0.99 ⇒ 6) 0.09 ⇒ 7) 1.09 ⇒ 8) 3.99 ⇒

ALGEBRA AND SCIENTIFIC NOTATION Worksheet C

Solve for z. Express answers 5 – 13 in scientific notation.

1) 5z = 15

2) 5z + 20 = 15

3) 6 + 5z = 26

4) 5z – 10 = 25 – 2z
5) \((3.0 \times 10^7)z = (1.8 \times 10^4)\) 
6) \((1.6 \times 10^{-6})z = (8.0 \times 10^4)(4.0 \times 10^{-8})\) 

7) \((3.2 \times 10^7) = (1.6 \times 10^{-2})z\) 
8) \((5.5 \times 10^2) = (1.1 \times 10^6)z\) 

9) \(\frac{(4.8 \times 10^{-9})}{(2.0 \times 10^7)} = (1.2 \times 10^{-6})z\) 
10) \((5.0 \times 10^4)z = 9,500\) \((2.5 \times 10^6)\) 

11) \(\frac{2.5}{10} = 5.5 \times 10^5\) \(z\) 
12) \(\frac{5.0 \times 10^2}{1 \times 10^3} = \frac{5.5 \times 10^5}{(1 \times 10^6)z}\) 

13) \((2.0 \times 10^{21}) = 125,000,000,000z\) 

---

**SIGNED NUMBERS, EXPONENTS AND SCIENTIFIC NOTATION Worksheet D**

**Signed numbers**

1) \(4 + (-5) =\)  
2) \((-5) + (-7) =\)  
3) \((-19) - 3 =\)  

4) \((-6) - (-4) =\)  
5) \(-7 - (-9) =\)  
6) \(13 x (-2) =\)  

7) \((-6) \div (-2) =\)  
8) \((3) x (-9) x (-5) =\)  
9) \((-6) x (-3) x (-4) =\)
Exponents
Write the following expressions in standard notation.

10) \(10^{-5} = \)

11) \(10^5 = \)

12) \(\frac{1}{10^5} = \)

13) \(\frac{1}{10^{-3}} = \)

Simplify the following expressions and then write in standard notation.

Write your answer as in this example: \(10^4 \times 10^2 = 10^6 = 1,000,000\)

14) \(10^2 \times 10^6 = \)

15) \(10^{-4} \times 10^9 = \)

16) \(10^{-4} \times 10^4 = \)

17) \(\frac{10^6}{10^3} = \)

18) \(\frac{10^{-6}}{10^{-3}} = \)

19) \(10^3 \times 3^6 = \)

Write the following numbers in standard notation.
Examples: \(4.26 \times 10^7 = 42,600,000\) \(3.2 \times 10^{-5} = 0.000032\)

20) \(3.0 \times 10^8 = \)

21) \(9.2 \times 10^{-8} = \)

22) \(\frac{14}{10^9} = \)

23) \(\frac{1.5}{10^{-7}} = \)

24) \(7.3 \times 10^{-4} = \)

25) \(6.7 \times \frac{1}{10^{-3}} = \)

Please note these relationships:
\[10^{-3} = \frac{1}{10^3} = \frac{1}{1000} = 0.001\]

*Please note: Any number raised to the power of 0 is 1.
\(10^0 = 1\) and \(3^0 = 1\)
Write the following numbers in scientific notation.

26) \(254.4 \times 10^{-3} = \)

27) \(62.01 \times 10^{4} = \)

28) \(0.09 \times 10^{2} = \)

29) \(111 \times 10^{-7} = \)

30) \(\frac{12}{10^{-5}} = \)

Perform the following operations and then write the answers in a) standard notation and b) scientific notation.

31) \(\frac{3.6}{3.0 \times 10^{5}} = \)

32) \(\frac{4.8 \times 10^{5}}{4.0 \times 10^{-5}} = \)

33) \((7.0 \times 10^{-3})(2.0 \times 10^{6}) = \)

34) \((2.5 \times 10^{-5})(5.0 \times 10^{-1}) = \)

35) \(\frac{18.0 \times 10^{-5}}{6.0 \times 10^{-3}} = \)
36) \[ \frac{(8.4 \times 10^{-2})}{(4.2 \times 10^{4})} \]  
\[ \text{a) } \] 
\[ \text{b) } \]

37) \[ \frac{(5.0 \times 10^{-7})(8.0 \times 10^{5})}{(4.0 \times 10^{-2})} \]  
\[ \text{a) } \] 
\[ \text{b) } \]

To do questions 38 & 39 without a calculator, use the distributive property / common factor method to solve the problems.

38) \( (2.0 \times 10^{3}) + (451.0 \times 10^{3}) = \)  
\[ \text{a) } \] 
\[ \text{b) } \]

39) \( (8.0 \times 10^{-17}) + (6.0 \times 10^{-15}) = \)  
\[ \text{a) } \] 
\[ \text{b) } \]

**METRIC CONVERSIONS Worksheet E**

Please remember that a measurement has two parts: a number and a unit. ALWAYS write both parts whenever you convert or take a measurement.

Solve the following problems. Show all work. 
Write the answers in \text{a) standard notation and} \text{ b) scientific notation.}

1. Convert 30 mg to g.  
\[ \text{a) } \] 
\[ \text{b) } \]

2. How many \( \mu l \) are there in 6.5 nl?  
\[ \text{a) } \] 
\[ \text{b) } \]

3. Convert 22 L to \( \mu l \).  
\[ \text{a) } \] 
\[ \text{b) } \]
4. How many m are there in 25 mm?  
   a)  
   b)  

5. Calculate the number of ng in 3 g.  
   a)  
   b)  

6. Convert 62 pg to g.  
   a)  
   b)  

7. How many µl are there in 390 pl?  
   a)  
   b)  

8. Convert 69 mg to pg.  
   a)  
   b)  

9. How many pm are there in 44 nm?  
   a)  
   b)  

10. Calculate the number of kg in 5 pg.  
    a)  
    b)  

11. One meter has how many cm?  
    a)  
    b)
RATIOS AND PROPORTIONS Worksheet F

Determine whether each of the following pairs of ratios are proportional.

1) \( \frac{3\text{mg}}{5\text{ml}} \) and \( \frac{57\text{mg}}{95\text{ml}} \)
2) \( \frac{60\text{g}}{10 \text{ tablets}} \) and \( \frac{15\text{g}}{2 \text{ tablets}} \)
3) \( \frac{240 \text{ cells}}{0.4\text{ml}} \) and \( \frac{5,400 \text{ cells}}{9\text{ml}} \)

Solve for the unknown value. Do not forget to include the unit of measurement.

4) \( \frac{500 \text{ m}}{0.5 \text{ km}} = \frac{z}{4 \text{ km}} \)
5) \( \frac{20\text{mg NaCl}}{2 \text{ tablets}} = \frac{80 \text{ mgNaCl}}{z} \)

Solve the following problems using ratio and proportion math:

6) 1ml of ethanol dissolved in a total volume of 8ml is the same as dissolving 3ml of ethanol in what total volume?

7) A patient needs to take one 200mg dose of vitamin B6 daily. The tablets she purchased from the drugstore are 50mg each. To take the correct dose, how many tablets should the patient take?

8) A solution contains 3mg/ml of Protein M. A scientist needs 12mg of Protein M for his experiment. How many ml of Protein M solution does the scientist need?

9) A solution made by dissolving 0.35g of sodium bicarbonate in 25 ml water has the same concentration as a solution prepared by dissolving 1.05g of sodium bicarbonate in how many ml of water?

10) A student prepares a solution containing 5 mg of sodium chloride in 150ml of water. The next day the student prepares a solution of the same concentration, but this time prepares it in 600ml of water. How many mg of sodium chloride did the student need to make this solution?
11) A pharmacist dispenses 20 potassium tablets to a patient. If each tablet contains 600mg, what is the total milligram quantity of potassium dispensed to the patient?

12) A blood sample contains 100 cells/0.02mL. How many cells per ml is this?

13) A student has 15ml of cells growing in culture. She determines that her cell population has a concentration of 1000 cells/ml. How many cells in total does the student have?

14) A technician needs to grow bacteria for an experiment. The growth medium for the bacteria requires 0.5 g of glucose per liter. The technician has prepared some medium by adding 3.6g of glucose in a total volume of 6.2 liters. Did she make the solution correctly?

15) You have a liter of a solution with a concentration of 0.4g/ml of enzyme. You need 2g of enzyme for an experiment. How much of the solution do you take?

16) A scientist has two sodium chloride solutions. Solution A has 25mg in 80ml, Solution B has 216 mg in 400ml.
   Calculate the number of mg per ml for each solution:
   Solution A: ____________  Solution B: ____________

   Which solution has the higher concentration? ____________

17) A scientist has bacteria growing in two flasks. In tube A he has $1 \times 10^7$ bacteria in 0.05L of culture fluid. In tube B he has $5.5 \times 10^5$ bacteria in 10ml. Write answers in scientific notation.
   Calculate the number of bacteria per ml in each flask
   Flask A: ____________  Flask B: ____________

   Which flask has the higher concentration? ____________
18) A lab supervisor tells a student to dissolve 6mg of Protein X in a total of 15ml buffer. The student is distracted by a text message and when she prepares the solution, she accidentally dissolves 8mg in 16ml.

a) Is the concentration of the solution the student prepared higher or lower than the required concentration? Show the calculation that allowed you to arrive at this answer.

b) The student asks her supervisor if she can start over. However, the student is told that Protein X is very expensive and she cannot start over. Instead, the student needs to adjust the volume to reach the required concentration. How does she do this?

19) You have a solution of Protein Z with a concentration of 7 mg/mL. You take 0.2mL of the solution and add 0.3mL of water. What is the final concentration of Protein Z?

20) You have a solution of Protein M with a concentration of 5 mg/mL. You take 9 mL of the solution and add 16 mL of water. What is the final concentration of Protein M?

21) A tube contains 10ml of solution of Protein Z. Each ml contains 3.2mg of Protein Z. How many tubes of Protein Z solution are needed for an experiment requiring 3200mg?

---

**ANSWERS TO LAB MATH PROBLEMS**

Answers are in red print.

**CONVERTING BETWEEN FRACTIONS, DECIMALS AND PERCENTS Worksheet A**

1) Convert from decimal to percent.
   \[ 0.067 = \boxed{6.7\%} \]

2) Convert from percent to decimal.
   \[ 1.6\% = \boxed{0.016} \]
3) Convert from fraction to decimal.
\[ \frac{3}{600} = 0.005 \]

4) Convert from decimal to fraction.
\[ 0.06 = \frac{3}{50} \]

5) Convert from percent to fraction.
\[ 78\% = \frac{39}{50} \]

6) Convert from fraction to percent.
\[ \frac{5}{40} = 12.5\% \]

ROUNDING NUMBERS Worksheet B

Round the following numbers to one decimal place
1) 3.24 ⇒ 3.2
2) 5.298 ⇒ 5.3
3) 6.25 ⇒ 6.3
4) 0.56 ⇒ 0.6

5) 0.99 ⇒ 1.0
6) 0.09 ⇒ 0.1
7) 1.09 ⇒ 1.1
8) 3.99 ⇒ 4.0

ALGEBRA AND SCIENTIFIC NOTATION Worksheet C

Solve for z. Express answers 5 – 13 in scientific notation.

1) 5z = 15 \[ z = 3 \]

2) 5z + 20 = 15
\[ 5z = 15 – 20 \]
\[ 5z = -5 \]
\[ z = -1 \]

3) 6 + 5z = 26
\[ 5z = 26 – 6 \]
\[ 5z = 20 \]
\[ z = 4 \]

4) 5z – 10 = 25 – 2z
\[ 5z + 2z = 25 + 10 \]
\[ 7z = 35 \]
\[ z = 5 \]

5) \((3.0 \times 10^7)z = (1.8 \times 10^4)\)
\[ z = (1.8 \times 10^4) \]
\[ (3.0 \times 10^7) \]
\[ z = 0.6 \times 10^{-3} \]
\[ z = 6.0 \times 10^{-4} \]

6) \((1.6 \times 10^{-6})z = (8.0 \times 10^4)(4.0 \times 10^{-8})\)
\[ z = (8.0 \times 10^4) \]
\[ (4.0 \times 10^{-8}) \]
\[ z = (1.6 \times 10^{-6}) \]
\[ z = 2.0 \times 10^3 \]

7) \((3.2 \times 10^7) = (1.6 \times 10^{-2})z\)
\[ \frac{3.2 \times 10^7}{1.6 \times 10^{-2}} = z \]
\[ 2.0 \times 10^{9} = z \]

8) \((5.5 \times 10^2) = (1.1 \times 10^6)z\)
\[ \frac{5.5 \times 10^2}{1.1 \times 10^6} = z \]
\[ 5.0 \times 10^{-4} = z \]
9) \( \frac{(4.8 \times 10^{-9})}{(2.0 \times 10^3)} = (1.2 \times 10^{-6})z \)

\( 2.4 \times 10^{-16} = (1.2 \times 10^{-6})z \)

\( 2.4 \times 10^{-16} = z \)

\( \frac{(1.2 \times 10^{-6})}{(1.2 \times 10^{-6})} \)

\( 2.0 \times 10^{-10} = z \)

10) \( \frac{(5.0 \times 10^4)z}{(2.5 \times 10^6)} = 9,500 \)

\( (5.0 \times 10^4)z = (9,500)(2.5 \times 10^{-6}) \)

\( z = \frac{(9,500)(2.5 \times 10^{-6})}{(5.0 \times 10^4)} \)

\( z = 4.75 \times 10^{-7} \)

11) \( \frac{2.5}{10} = \frac{5.5 \times 10^5}{z} \)

use cross multiplication

\( (2.5)z = 10(5.5 \times 10^5) \)

\( z = \frac{(5.5 \times 10^6)}{2.5} \)

\( z = 2.2 \times 10^6 \)

12) \( \frac{5.0 \times 10^2}{1 \times 10^4} = \frac{5.5 \times 10^5}{z} \)

\( 1 \times 10^{-6} \)

\( z = \frac{5.5 \times 10^5}{(1 \times 10^{-6})} \)

\( z = 1.1 \times 10^5 \)

13) \( 2.0 \times 10^{21} = 125,000,000,000z \)

\( \text{Convert to scientific notation} \)

\( 2.0 \times 10^{21} = (1.25 \times 10^{11})z \)

\( (2.0 \times 10^{21}) = z \)

\( (1.25 \times 10^{11}) \)

\( 1.6 \times 10^{10} = z \)

---

**SIGNED NUMBERS, EXPONENTS AND SCIENTIFIC NOTATION Worksheet D**

**Signed numbers**

1) \( 4 + (-5) = -1 \)

2) \( (-5) + (-7) = -12 \)

3) \( (-19) - 3 = -22 \)

4) \( (-6) - (-4) = -2 \)

5) \( -7 - (-9) = 2 \)

6) \( 13 \times (-2) = -26 \)

7) \( (-6) \div (-2) = 3 \)

8) \( (3 \times (-9)) \times (-5) = 135 \)

9) \( (-6) \times (-3) \times (-4) = -72 \)
Exponents
Write the following expressions in standard notation.
10) \(10^{-5} = 0.00001\)

11) \(10^5 = 100,000\)

12) \(\frac{1}{10^5} = 0.00001\)

13) \(\frac{1}{10^3} = 100,000\)

Simplify the following expressions and then write in standard notation.
Write your answer as in this example: \(10^4 \times 10^2 = 10^6 = 1,000,000\)

14) \(10^2 \times 10^6 = 10^8 = 100,000,000\)

15) \(10^{-4} \times 10^9 = 10^5 = 100,000\)

16) \(10^{-4} \times 10^4 = 10^0 = 1\)

17) \(\frac{10^6}{10^3} = 1000\)

18) \(\frac{10^{-6}}{10^{-3}} = 0.001\)

19) \(10^3 \times 3^6 = 1000 \times 729 = 729,000\)

*Bases are different, therefore exponents cannot be added!*

20) \(3.0 \times 10^8 = 300,000,000\)

21) \(9.2 \times 10^{-8} = 0.000000092\)

22) \(\frac{14}{10^9} = 1.4 \times 10 \times 10^{-9} = 1.4 \times 10^{-8} = 0.000000014\)

23) \(1.5 \times 10^{-7} = 1.5 \times 10^7 = 15,000,000\)

24) \(7.3 \times 10^{-4} = 0.00073\)

25) \(6.7 \times \frac{1}{10^{-3}} = 6.7 \times 10^3 = 6700\)

Please note these relationships:
\[10^{-3} = \frac{1}{1000} = \frac{1}{10^3} = 0.001\]
Write the following numbers in scientific notation.

26) $254.4 \times 10^{-3} = (2.544 \times 10^2) \times 10^{-3} = 2.544 \times 10^{-1}$

27) $62.01 \times 10^4 = (6.201 \times 10^1) \times 10^4 = 6.201 \times 10^5$

28) $0.09 \times 10^2 = (9 \times 10^{-2}) \times 10^2 = 9 \times 10^0 = 9$

29) $111 \times 10^{-7} = (1.11 \times 10^2) \times 10^{-7} = 1.11 \times 10^{-5}$

30) $\frac{12}{10^{-5}} = 1.2 \times 10^1 \times 10^5 = 1.2 \times 10^6$

Perform the following operations and then write the answers in
a) standard notation and      b) scientific notation.

31) \[
\frac{3.6}{3.0 \times 10^5} = 1.2 \times 10^{-5}
\]

a) 0.000012

b) $1.2 \times 10^{-5}$

32) \[
\frac{4.8 \times 10^5}{4.0 \times 10^{-5}} = 1.2 \times 10^5 \times 10^5
\]

a) $12,000,000,000$

b) $1.2 \times 10^{10}$

33) \[
(7.0 \times 10^{-3})(2.0 \times 10^6) = 14 \times 10^3 = 1.4 \times 10 \times 10^3
\]

a) 14,000

b) $1.4 \times 10^4$

34) \[
(2.5 \times 10^{-5})(5.0 \times 10^{-1}) = 12.5 \times 10^{-6}
\]

a) 0.0000125

b) $1.25 \times 10^{-5}$

35) \[
\frac{(18.0 \times 10^{-5})}{(6.0 \times 10^{-3})} = 3.0 \times 10^{-5} \times 10^3
\]

a) 0.03

b) $3.0 \times 10^{-2}$

36) \[
\frac{(8.4 \times 10^{-7})}{(4.2 \times 10^4)} = 2.0 \times 10^{-2} \times 10^{-4}
\]

a) 0.000002

b) $2.0 \times 10^{-6}$

37) \[
\frac{(5.0 \times 10^{-7})(8.0 \times 10^5)}{(4.0 \times 10^{-2})} = 10 \times 10^{-2} \times 10^2
\]

a) 10

b) $1.0 \times 10$
To do questions 38 & 39 without a calculator, use the distributive property / common factor method to solve the problems.

38) \((2.0 \times 10^3) + (451.0 \times 10^3) = 10^3 (2.0 + 451.0)\)  
a) 453,000  
b) \(4.53 \times 10^5\)

10^3 is the common factor for both expressions

39) \((8.0 \times 10^{-17}) + (6.0 \times 10^{-15}) = (8.0 \times 10^{-2} \times 10^{-15}) + (6.0 \times 10^{-15})\)  
a) 0.00000000000000608  
b) \(6.08 \times 10^{-15}\)

10^{-15} is a common factor for both expressions

METRIC CONVERSIONS Worksheet E

Please remember that a measurement has two parts: a number and a unit. ALWAYS write both parts whenever you convert or take a measurement.

Solve the following problems. Show all work.

Write the answers in a) standard notation and b) scientific notation.

1. Convert 30 mg to g.  
a) 0.03 g  
b) \(3.0 \times 10^{-2}\) g

   Use the relationship \(1\text{g} = 1 \times 10^3\) mg

   \[
   30\text{mg} \times \frac{1\text{g}}{1 \times 10^3\text{mg}} = 30 \times 10^{-3} = 3 \times 10^{-2}\text{g}
   \]

2. How many µl are there in 6.5 nl?  
a) 0.0065 µl  
b) \(6.5 \times 10^{-3}\) µl

   Use the relationship \(1\mu\text{l} = 1 \times 10^3\) nl

3. Convert 22 L to µl.  
a) 22,000,000 µl  
b) \(2.2 \times 10^7\) µl

   Use the relationship \(1\text{l} = 1 \times 10^6\) µl

4. How many m are there in 25 mm?  
a) 0.025 m  
b) \(2.5 \times 10^{-2}\) m

   Use the relationship \(1\text{m} = 1 \times 10^3\) mm

5. Calculate the number of ng in 3 g.  
a) 3,000,000,000 ng  
b) \(3 \times 10^9\) ng

   Use the relationship \(1\text{g} = 1 \times 10^9\) ng
6. Convert 62 pg to g.

Use the relationship \( 1 g = 1 \times 10^{12} \text{ pg} \)

a) \( 0.000000000062 \text{ g} \)

b) \( 6.2 \times 10^{-11} \text{ g} \)

7. How many µl are there in 390 pl?

Use the relationship \( 1 \mu l = 1 \times 10^6 \text{ pl} \)

a) \( 0.00039 \mu l \)

b) \( 3.90 \times 10^{-4} \mu l \)

8. Convert 69 mg to pg.

Use the relationship \( 1 \text{ mg} = 1 \times 10^9 \text{ pg} \)

a) \( 69,000,000,000 \text{ pg} \)

b) \( 6.9 \times 10^{10} \text{ pg} \)

9. How many pm are there in 44 nm?

Use the relationship \( 1 \text{ nm} = 1 \times 10^3 \text{ pm} \)

a) \( 44,000 \text{ pm} \)

b) \( 4.4 \times 10^4 \text{ pm} \)

10. Calculate the number of kg in 5 pg.

Use two relationships: \( 1 g = 1 \times 10^{12} \text{ pg} \)

\( 1 \text{ kg} = 1 \times 10^3 \text{ g} \)

First convert pg to g, then convert g to kg

a) \( 0.000000000000005 \text{ kg} \)

b) \( 5 \times 10^{-15} \text{ kg} \)

11. One meter has how many cm?

Use the relationship \( 1 \text{ m} = 1 \times 10^2 \text{ cm} \)

a) \( 100 \text{ cm} \)

b) \( 1 \times 10^2 \text{ cm} \)

**RATIOS and PROPORTIONS Worksheet F**

Determine whether each of the following pairs of ratios are proportional.

1) \( \frac{3 \text{ mg}}{5 \text{ ml}} \) and \( \frac{57 \text{ mg}}{95 \text{ ml}} \)

2) \( \frac{60 \text{ g}}{10 \text{ tablets}} \) and \( \frac{15 \text{ g}}{2 \text{ tablets}} \)

3) \( \frac{240 \text{ cells}}{0.4 \text{ ml}} \) and \( \frac{5,400 \text{ cells}}{9 \text{ ml}} \)

\[
\begin{align*}
3 \times 95 &= 285 \\
5 \times 57 &= 285 \text{ yes} \\
60 \times 2 &= 120 \\
10 \times 15 &= 150 \text{ no} \\
240 \times 9 &= 2160 \\
5,400 \times 0.4 &= 2160 \text{ yes}
\end{align*}
\]
Solve for the unknown value. Do not forget to include the unit of measurement.

4) \[ \frac{500 \text{ m}}{0.5 \text{ km}} = \frac{z}{4 \text{ km}} \]

\[ 500 \text{ m} \times 4 \text{ km} = 0.5 \text{ m} \times z \]

\[ z = 4000 \text{ m} \]

5) \[ \frac{20 \text{ mg NaCl}}{2 \text{ tablets}} = \frac{80 \text{ mg NaCl}}{z} \]

\[ 20 \text{ mg} \times z = 80 \text{ mg} \times 2 \text{ tablets} \]

\[ z = 8 \text{ tablets} \]

Solve the following problems using ratio and proportion math:

6) 1ml of ethanol dissolved in a total volume of 8ml is the same as dissolving 3ml of ethanol in what total volume?

\[ \frac{1 \text{ ml ethanol}}{8 \text{ ml}} = \frac{3 \text{ ml}}{x} \]

\[ x = 24 \text{ ml} \]

7) A patient needs to take one 200mg dose of vitamin B6 daily. The tablets she purchased from the drugstore are 50mg each. To take the correct dose, how many tablets should the patient take?

\[ \frac{50 \text{ mg}}{1 \text{ tablet}} = \frac{200 \text{ mg}}{z} \]

\[ z = 4 \text{ tablets} \]

8) A solution contains 3mg/ml of Protein M. A scientist needs 12mg of Protein M for his experiment. How many ml of Protein M solution does the scientist need?

\[ \frac{3 \text{ mg}}{\text{ ml}} = \frac{12 \text{ mg}}{z} \]

\[ z = 4 \text{ ml} \]

9) A solution made by dissolving 0.35g of sodium bicarbonate in 25 ml water has the same concentration as a solution prepared by dissolving 1.05g of sodium bicarbonate in how many ml of water?

\[ \frac{0.35 \text{ g}}{25 \text{ ml}} = \frac{1.05 \text{ g}}{75 \text{ ml}} \]

10) A student prepares a solution containing 5 mg of sodium chloride in 150ml of water. The next day the student prepares a solution of the same concentration, but this time prepares it in 600ml of water. How many mg of sodium chloride did the student need to make this solution?

\[ \frac{5 \text{ mg}}{150 \text{ ml}} = \frac{20 \text{ mg}}{600 \text{ ml}} \]
11) A pharmacist dispenses 20 potassium tablets to a patient. If each tablet contains 600mg, what is the total milligram quantity of potassium dispensed to the patient? \[ \frac{600\text{mg}}{\text{tablet}} \times \frac{20\text{ tablets}}{} = 12,000\text{mg} \]

12) A blood sample contains 100 cells/0.02mL. How many cells per ml is this? \[ \frac{100\text{ cells}}{0.02\text{ml}} = \frac{5000\text{ cells}}{1\text{ml}} \]

13) A student has 15ml of cells growing in culture. She determines that her cell population has a concentration of 1000 cells/ml. How many cells in total does the student have? \[ \frac{1000\text{ cells}}{1\text{ml}} \times \frac{15\text{ml}}{} = 15,000\text{ cells total} \]

14) A technician needs to grow bacteria for an experiment. The growth medium for the bacteria requires 0.5 g of glucose per liter. The technician has prepared some medium by adding 3.6g of glucose in a total volume of 6.2 liters. Did she make the solution correctly? NO \[ \frac{0.5\text{g}}{1\text{L}} \neq \frac{3.6\text{g}}{6.2\text{L}} \]

15) You have a liter of a solution with a concentration of 0.4g/ml of enzyme. You need 2g of enzyme for an experiment. How much of the solution do you take? \[ \frac{0.4\text{g}}{\text{ml}} \times \frac{2\text{g}}{x} = \frac{5\text{ml}}{} \]

16) A scientist has two sodium chloride solutions. Solution A has 25mg in 80ml, Solution B has 216 mg in 400ml. Calculate the number of mg per ml for each solution:
   Solution A: \[ 0.3125 \text{ mg/ml} \]
   Solution B: \[ 0.54 \text{ mg/ml} \]
   Which solution has the higher concentration? Solution B

17) A scientist has bacteria growing in two flasks. In tube A he has \(1 \times 10^7\) bacteria in 0.05L of culture fluid. In tube B he has \(5.5 \times 10^5\) bacteria in 10ml. Write answers in scientific notation.
   Calculate the number of bacteria per ml in each flask:
   Flask A: \[ 2 \times 10^5 \text{ bacteria/ml} \]
   Flask B: \[ 5.5 \times 10^4 \text{ bacteria/ml} \]
   Which flask has the higher concentration? A
18) A lab supervisor tells a student to dissolve 6mg of Protein X in a total of 15ml buffer. The student is distracted by a text message and when she prepares the solution, she accidentally dissolves 8mg in 16ml.

c) Is the concentration of the solution the student prepared higher or lower than the required concentration? Show the calculation that allowed you to arrive at this answer.

\[
\begin{align*}
\frac{6mg}{15ml} &= 0.4mg/1ml \\
\frac{8mg}{16ml} &= 0.5mg/1ml \\
&\text{Higher}
\end{align*}
\]

d) The student asks her supervisor if she can start over. However, the student is told that Protein X is very expensive and she cannot start over. Instead, the student needs to adjust the volume to reach the required concentration. How does she do this?

\[
\begin{align*}
\frac{6mg}{15ml} &= \frac{8mg}{x} \\
x &= 20ml \\
&\text{Student needs to add 4ml to the 16ml of the solution she prepared incorrectly to achieve the correct concentration}
\end{align*}
\]

19) You have a solution of Protein Z with a concentration of 7 mg/mL. You take 0.2mL of the solution and add 0.3mL of water. What is the final concentration of Protein Z?

\[
\begin{align*}
\frac{7mg}{ml} &= \frac{x}{0.2ml} \\
x &= 1.4mg \text{ (in 0.2ml)} \\
\frac{1.4mg}{0.5ml} &= \frac{z}{1ml} \\
z &= 2.8mg \\
&\text{(total final volume)}
\end{align*}
\]

final concentration of Protein Z is 2.8mg/ml

20) You have a solution of Protein M with a concentration of 5 mg/mL. You take 9 mL of the solution and add 16mL of water. What is the final concentration of Protein M?

\[
\begin{align*}
\frac{5mg}{ml} &= \frac{x}{9ml} \\
x &= 45mg \text{ (in 9ml)} \\
\frac{45mg}{25ml} &= \frac{z}{1ml} \\
z &= 1.8mg \\
&\text{(total final volume)}
\end{align*}
\]

final concentration of Protein M is 1.8mg/ml

21) A tube contains 10ml of solution of Protein Z. Each ml contains 3.2mg of Protein Z. How many tubes of Protein Z solution are needed for an experiment requiring 3200mg? 100 tubes

\[
\frac{3.2 mg}{ml} = \frac{32mg}{10ml} = \frac{32mg}{1 tube} = 3200mg \text{ tube} = 100 \text{ tubes}
\]