Worksheet: Appropriate Prefix to Exponent and Other Combinations

1. Exponential Math
2. Movement of decimal points
3. Knowing your prefix to exponential power equality
4. Prefix/exponential math

1. Exponential Math

We begin with basic exponential math. You must to feel comfortable doing basic operations with exponents: multiplication and division. Most (if not all) of the numberical problems are in base 10.

MULTIPLICATION: Exponential powers are added in this operation.

$10^a x 10^b = 10^{a+b}$
Example: $8x10^4x^6= 8x10^{10}$. Also, consider the reverse process; what does the sum of the exponents represent?
Example: $7x10^{12}=7x10^{11+1}=7x10^{11}x10^1=7x10^{9+3}=7x10^9x10^3$ and so on.

DIVISION: Exponential powers are subtracted in this operation.

$10^a/10^b= 10^{a-b}$
Example: $(8x10^3)/10^9= 8x10^{-6}$. $(4x10^{-2})/2x10^{-4}) = 2x10^2$

ROOTS AND POWERS: When presented with a problem that involves a power, multiple the power by the exponential value; when the problem involves roots, divide the exponential value by the root.
[rule of thumb] We will probably not have any powers or roots that exceed 3 , because a power of 2 represents an area, and a power of 3 represents a volume in terms of units, be prepared to work outside of the box.
$(10^a)^b = 10^{axb}$
Example: $(4x10^2)^2= 4x10^2x4x10^2= 16x10^4$
Example: $4\sqrt{10^{16}}$ [read as 4th root of 10^{16}] $= 10^{16/4}=10^4$
Example: $3\sqrt{(27x10^{-15})} = 3\sqrt{(27)}\ x3\sqrt{(10^{-15})}=3x10^{-5}$

2. Movement of decimal points

Moving the decimal point is the same as multiplying (x) or dividing (/) by 10. This is a skill that you want to become very adept at. Practice makes perfect.
Move decimal to the right (→) is like dividing by 10; move the decimal to the left (←) is like multiplying by 10.
Example: $85.0=8.50x10^1=850x10^{-1}$.
Example: $7.9x10^{-3}=79x10^{-4}=0.79x10^{-2}$
Example: These are the same number, but expressed differently with scientific notation Check it in your calculator!!

$8.639x10^5 = 8.639x10^2x10^3 = 8639x10^2 = 86.39x10^2x10^2 = 8.639x10^1x10^2x10^2$

3. Knowing your prefix to exponential power equality

You need to know your prefix/power connections. They are in your book and on website under **CHAPTER 1 HANODOUTS**. You need to know the highlighted terms for the test, but should feel compfortable using all of them.

Prefix	symbol	equivalent	factor
atto	a	quintillionth part	10^{-18}
femto	f	quadrillionth part	10^{-15}
pico	p	trillionth part	10^{-12}
nano	**n**	**billionth part**	10^{-9}
micro	**μ**	**millionth part**	10^{-6}
milli	**m**	**thousandth**	10^{-3}
centi	**c**	**hundredth**	10^{-2}
deci	**d**	**tenth**	10^{-1}
deca	da	tenfold	10
hecto	h	hundred fold	10^2
kilo	**k**	**thousand fold**	10^3
mega	**M**	**million fold**	10^6
giga	**G**	**billion fold**	10^9
tera	T	trillion fold	10^{12}

4. Prefix/exponential math

There are several types of problems that involve taking a number that is not presented in the appropriate prefix and scientific notation and turning it into an appropriate prefix, or reversing that process. We want to represent the number in such a way that the exponent is as small as possible and most of the decimal power is absorbed in the prefix. The power or exponent is often referred to as the 'characteristic' and the decimal value is called the 'mantissa'.

4.1 Basic type

In the basic conversion, you are given a value that is written in either proper scientific notation, or improper scientific notation and the base unit has no prefix. In this type of problem, we want to turn the characteristic (power) into a base unit.

Example: Write $1.8 x10^{-7}$g using the appropriate prefix.

Notice that the exponent is a small negative number. We want to change this exponent [power, characteristic] into a prefix. When looking at the exponential [characteristic] value, —7, we think —1 + —6 = —7. We can write this problem as $1.8 x 10^{-1}x10^{-6}$. Do you know a prefix for either —1 or —6? We want to prefix to absorb the most decimal places as possible. So, choosing the prefix for —1, deci [d], doesn't make a lot of sense. However, 10^{-6} is the prefix micro [μ], a prefix that uses most of the "power", and this allows us to reduce the number [mantissa] to a reasonable value.

The value can be reduced to $1.8 x 10^{-1}$μg; ideally, we would like to have numbers have no exponents if possible. Let's get rid of that —1 exponent. We can do that by moving the decimal to the left. The final answer is 0.18 μg.

Now you try: 2.74 8x10^{14}mol

Answer: 0.274 8 Pmol. We use P [peta] or 10^{15} as an appropriate prefix. We need to write the number such that we can use the peta prefix, but not change the magnitude of the number. The number can be written in a variety of ways. 14 + 1 = 15, so we need to write our exponents in such a way that we get 15 as a power. Inserting two exponential values, $10^{—1}$ and 10^{1}, into the number does not change the magnitude of the number, because this makes 10^{0} or 1.

2.748x10^{14}mol = 2.748x$10^{—1}$x10^{1}x10^{14}mol = (2.748x$10^{—1}$)x10^{1}x10^{14}mol = 0.274 8 x10^{1}x10^{14}mol = 0.274 8x10^{15}mol = 0.274 8 Pmol

a. Write 5.612 83 x$10^{—17}$sec using the appropriate prefix.

Answer: 0.0561 283 fsec. We can use femto [f] or $10^{—15}$ as an appropriate prefix. We need to write the number such that we can use the femto prefix, but not change the magnitude of the number. —17 + 2 = —15, so we need to write our exponents in such a way that we get 15 as a power. we inserted two exponential values, $10^{—2}$ and 10^{2}, into the number. Doing so does not change the magnitude of the number, because it is as if we multiplied by one. we cleared out our exponents and we put it into the proper prefix.

5.612 83 x$10^{—17}$sec= 5.612 83 x$10^{—2}$x10^{2}x$10^{—17}$sec=(5.612 83 x$10^{—2}$)x10^{2}x$10^{—17}$sec=0.0561 283 x$10^{—15}$sec= 0.0561 283fsec

b. Write 634,983 x$10^{—13}$g using the appropriate prefix

Answer: 63.498 3 ng. First, we must put the number into proper scientific notation. Then we assess which prefix would be the most appropriate. Looking at the number, we see that the exponent is close to nano [n], or $10^{—9}$ as an appropriate prefix. We need to write the number such that we can use the nano prefix, but not change the magnitude of the number. —8 + —1 = —9, so we need to write our exponents in such a way that we get —9 as a power. we inserted two exponential values, $10^{—1}$ and 10^{1}, into the number. Doing so does not change the magnitude of the number, because it is as if we multiplied by one. we cleared out our exponents and we put it into the proper prefix.

634 983 x$10^{—13}$g = 6.349 83 x10^{5}x$10^{—13}$g = 6.349 83x$10^{—8}$ g; 6.349 83x$10^{—8}$ g = (6.349 83 x10^{1})x$10^{—1}$x$10^{—8}$g = 63.498 3x$10^{—1}$x$10^{—8}$g = 63.498 x$10^{—9}$g = 63.498 3 ng
Now try these. Use the table in the book on page 16 for more prefixes:

1. 422 x$10^{—20}$g [4.22ag]
2. 82,123,616 x10^{9}amp [82.123 616 Pamp]
3. 1.23x10^{7}x$10^{—18}$m [12.3 pm]
4. 18.65 x$10^{—4}$g [1865 μg]

4.2 Basic type plus a prefix

In the "basic type plus a prefix" problem, one is given a value that is written in either proper scientific notation, or improper scientific notation and the base unit has a prefix. We begin these types of problems by first converting the prefix into an exponential value and reducing exponential

values to common exponent or characteristic. Now we have at number that's in proper scientific notation attached to a base unit and we look for the best prefix.

Write $1.6x10^{-4}$ km using the appropriate prefix.

Answer: As one can see from the problem, the exponent is a small number and the prefix represents a large number. We want to express this number as a simple decimal value, a prefix, and a base unit. First, we expand the prefix into its exponential value. Then we reduce the exponents to a single value and evaluate the resulting number for the best prefix. In general, these types of problems have very small exponential values coupled with prefixes that represent large values, or visa versa.

$1.6x10^{-4}$km = 1.6 $x10^{-4}x10^{3}$m = 1.6 $x10^{-1}$m. We can see from the list on page 16 in the text that 10^{-1} is the power for deci [d], so the best way to write this number is 1.6 dm.

Write $4.567x10^{-18}$Tg **using the appropriate prefix.**

Answer: 4.567µg. First, expand the exponents, so the number is now $4.567x10^{-18}x10^{12}$g. now reduce the exponents to a common value; the number is written as $4.567x10^{-6}$g. the best prefix will be the microgram, or 4.567µg.

Write 5.678 $90x10^{22}$ pmol using the appropriate prefix.

Answer: 56.789 0 Gmol. First, expand the exponents, so the number is now 5.678 90 $x10^{22}x10^{-12}$ mol. Now reduce the exponents to a common value; the number is written as 5.678 90 $x10^{10}$mol. the best prefix will be the gigamole, but, we must convert the value so that it is in the correct prefix. The giga prefix is represented by the value 10^{9}, so we can write the number thusly as 5.678 90 x $10^{1}x10^{9}$mol. The number reduces to 56.789 0 $x10^{9}$mol, or 56.789 0 Gmol.

4.3 Units Involving Powers

Measurements involving areas and volumes use units that are squared or cube. For example, an area can be expressed as m^2, cm^2, or even μm^2. When we square a unit, the prefix becomes squared too!

Let's express an area of a rectangle that is 12 cm by 28 cm. The answer is 336 $(cm)^2$ [we're ignoring significant figures for now.] It is very awkward to write the units with parenthesis all the time, so we take a short cut and write the value as 336 cm^2. Volumes are treated the same way.

We start the problem by figuring out the area of a rectangle that is $1.8x10^{-6}$cm by 2.0 $x10^{-8}$ cm. First, we calculate the answer of $3.6x10^{-14}cm^2$. This is not the best prefix because the absolute value of our exponential value is too big! We need to reduce it; let's expand the value and get to the base unit.

$3.6x10^{-14}cm^2$ = $3.6x10^{-14}$cm x cm= $3.6x10^{-14}x10^{-2}x10^{-2}$m x m = $3.6x10^{-18}$m x m. Now here is the tricky part. We need the prefix in front of the meter unit to be the same. They can be µm or pm but they must be the same prefix and they must get rid of the exponent. we need the exponent to be divisible by two. Fortunately for us, —18 is divisible by two and gives us —9. This is also fortunate because we have a prefix that represents 10^{-9}, nano [n]. we write the number thusly:

$3.6x10^{-18}$ m x m = $3.6x10^{-9}$ x 10^{-9} x m x m= $3.6x10^{-9}$ m x 10^{-9}m = 3.6 nm x nm = $3.6nm^2$.

The best representation of the area is **3.6nm^2**

Write 158 x10^{9}cm^2 **using the appropriate prefix.**

Answer: 15.8 km^2 This is not the best prefix because the absolute value of our exponential value is too big! We need to reduce it. Lets expand the value and get to the base unit.

1.58 x10^2 x10^{9}x10^{-2}x10^{-2} m x m = 1.58 x10^7 m x m. again we need to convert this to an exponent that is divisible by two. 1.58 x10^1 x10^6 m x m works. Re—writing this number

15.8 x10^3 x10^{3}m x m = 15.8 km^2

Try the following:

1. 123,456 nm^2 [1.234 56 μm^2]
2. 0.629 89 Mm^2 [62.989 km^2]

Going backwards to find a single dimension like a radius or height is just as easy.

Determine the radius of a sphere with a volume of 4.567 x10^{-28} km^3.

Convert the number to a base unit. 4.567 x10^{-28} km^3 becomes 4.567 x10^{-28} x10^{3}x10^{3}x10^3 and is reduced to 4.567 x10^{-19}m^3. This represents the volume of a sphere. The formula for the volume of a sphere is: $V = \frac{4}{3}\pi r^3$. Rearranging the formula to solve for r, $r = \sqrt[3]{\frac{3V}{4\pi}}$.
$\sqrt[3]{1.0903x10^{-19}}$=4.777X10^{-7}m. Turn this into a prefix: 4.777X10^{-1}x10^{-6}m or 0.4777μm.

The answer: The radius is 0.477 7 μm.[1,2]

Try the following:

1. This volume represents a cubic object. Find the length of a side whose volume is 1,897,656 fm^3 [0.001 897 656 pm^3]
2. This volume represents a cone, V $V = \frac{\pi r^2 h}{3}$ the height find the radius if the height is 0.010 000 Mm. and the volume is 0.000 030 000 Gm^3 [53.524Tm]

[1] Okay, now that you know the basics, consider looking at your answers when doing extra problems from the book. You can see from the handout, that practicing moving decimals, and exponential math is very important for using proper prefixes.

[2] If there are parts that are not clear, let me know so we can review and update this document. Eventually the practice problems will be part of this worksheet.