### Scientific Notation Study Guide

#### Standard Form → Scientific Notation
Written as a **decimal times 10 raised to an integer**
\[ d \times 10^n \]
- **d** = Decimal – A number between 1 and 10
- **n** = Integer – The number of times the decimal point is moved (THIS IS NOT THE NUMBER OF ZEROS!)

If you move the decimal point to the **LEFT** in order to create a number between 1 and 10, the **n** will be **positive**.
Ex. \( 3.73 \times 10^9 \) → \( 9.2 \times 10^4 \)

If you move the decimal point to the **RIGHT** in order to create a number between 1 and 10, the **n** will be **negative**.
Ex. \( 0.000000000086 \) → \( 8.6 \times 10^{-12} \)
\( 0.00000482 \) → \( 4.82 \times 10^{-6} \)

#### Scientific Notation → Standard Form
Move the decimal point the opposite way
- If the **n** in \( d \times 10^n \) is **POSITIVE**
  - **Move the decimal point to RIGHT** to put it back in to standard form.
Ex. \( 3.73 \times 10^9 \) → \( 3.73 \times 10,000,000,000 \)
\( 9.2 \times 10^4 \) → \( 9,200 \)

- If the **n** in \( d \times 10^n \) is **NEGATIVE**
  - **Move the decimal point to LEFT** to put it back in to standard form.
Ex. \( 8.6 \times 10^{-12} \) → \( 0.0000000000086 \)
\( 4.82 \times 10^{-6} \) → \( 0.000004.82 \)

#### Prime Number
- A number that only has two factors, 1 and itself; a number that divides evenly by only 1 and itself (Always an odd number with the exception of 2)
- \( 2, 3, 7, 11, 13, 17, 19, 23, 29, 31, 37, 43, 47, \ldots \)

\[ 10 = 2 \times 5 \]
\[ 12 = 2 \times 2 \times 3 \]
\[ 24 = 2 \times 2 \times 2 \times 3 \]
\[ (2 \times 5)^6 (2 \times 2 \times 3)^3 \]
\[ (2 \times 2 \times 3)^4 \]

#### Power to a Power Law
\[ (2 \times 5)^6 (2 \times 2 \times 3)^3 \]
\[ (2 \times 2 \times 3)^4 \]
\[ 2^{6}5^{6}2^{3}3^{3} \]
\[ 2^{4}2^{4}3^{4} \]

#### Product Law and Quotient Law
\[ \frac{2^{12}5^{6}3^{3}}{2^{12}3^{4}} = \frac{5^{6}3^{3}}{3^{4}} = \frac{5^{6}3^{-1}}{3^{4}} = \frac{5^{6}}{3^{1}} \]

#### Adding Numbers in Scientific Notation
Ex. \( 8.3 \times 10^{15} + 3.1 \times 10^{17} \)
In order to add two (or more) numbers written in scientific notation together, you **must have the same order of magnitude**.

Order of Magnitude – the exponents; or the **n** in \( d \times 10^n \)
Therefore you must take the **bigger exponent** (in this case \( 10^{17} \)) and break that up. Because you must have the same order of magnitude, **one of the exponents must be the second order of magnitude in the problem (in this case \( 10^{15} \)) when you expand \( 10^{17} \)
Therefore,
\[ 10^{17} = 10^{15} \times 10^{2} \]
\[ 8.3 \times 10^{15} + 3.1 \times 10^{15} \times 10^{2} \]

Use the **commutative (order) and associative (grouping)** properties to rewrite the problem.
\[ 8.3 \times 10^{15} + (3.1 \times 10^2) \times 10^{15} \]

Which exponent is not like the other? \(10^2\)

In order for us to get rid of \(10^2\), we must put \(3.1 \times 10^2\) into standard form by moving the decimal 2 times to the right.

\[ 3.1 \times 10^2 = 310 \]
\[ 8.3 \times 10^{15} + 310 \times 10^{15} \]

Using the distributive property, rewrite the problem as

\[ (8.3 + 310) \times 10^{15} \]

Simplify by adding the numbers in the parentheses

\[ 318.3 \times 10^{15} \]

Make sure the answer is in scientific notation by moving the decimal point

\[ 3.183 \times 10^2 \times 10^{15} = 3.183 \times 10^{17} \]

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**Subtracting Numbers in Scientific Notation**

Ex. \[ 9.4 \times 10^{28} - 5.8 \times 10^{26} \]

In order to subtract numbers written in scientific notation together, you must have the same order of magnitude.

Order of Magnitude – the exponents; or the \(n\) in \(10^n\)

Therefore you must take the bigger exponent (in this case \(10^{28}\)) and break that up. Because you must have the same order of magnitude, one of the exponents must be the second order of magnitude in the problem (in this case \(10^{26}\)) when you expand \(10^{28}\) to must be 102

\[ 10^{28} = 10^{26} \times 10^2 \]
\[ 9.4 \times 10^{26} \times 10^2 - 5.8 \times 10^{26} \]

Use the commutative (order) and associative (grouping) properties to rewrite the problem

\[ (9.4 \times 10^2) \times 10^{26} - 5.8 \times 10^{26} \]

Which exponent is not like the other? \(10^2\)

In order for us to get rid of \(10^2\), we must put \(9.4 \times 10^2\) into standard form by moving the decimal 2 times to the right.

\[ 9.4 \times 10^2 = 940 \]
\[ 940 \times 10^{26} - 5.8 \times 10^{26} \]

Using the distributive property, rewrite the problem as

\[ (940 - 5.8) \times 10^{26} \]

Simplify by subtracting the numbers in the parentheses

\[ 934.2 \times 10^{26} \]

Make sure the answer is in scientific notation by moving the decimal point

\[ 9.342 \times 10^2 \times 10^{26} = 9.342 \times 10^{28} \]

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**Multiplying Numbers in Scientific Notation**

Ex. \((3.2 \times 10^5)(7.1 \times 10^9)\)

Use the commutative property to change the order of the terms and the associative property to change the grouping

\[(3.2 \times 7.1)(10^5 \times 10^9)\]

Simplify by multiplying the decimal numbers and using the product law to simplify the exponents

\[22.72 \times 10^{5+9} = 22.72 \times 10^{14}\]

Make sure the answer is in scientific notation by moving the decimal point

\[2.272 \times 10^1 \times 10^{14} = 2.272 \times 10^{15}\]

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**Dividing Numbers in Scientific Notation**

Ex. \[\frac{10.5 \times 10^{35}}{4.2 \times 10^{28}}\]

Separate into two fractions. We can do this because the operation between the terms is multiplication.

\[\frac{10.5}{4.2} \times \frac{10^{35}}{10^{29}}\]

Simplify by dividing the decimal numbers and using the quotient law to simplify the exponents

\[2.5 \times 10^{35-29} = 2.5 \times 10^6\]