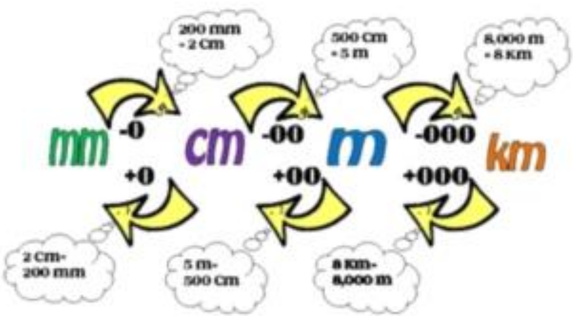
Chemistry 11

Unit 2: Introduction to Chemistry



Book 2: Unit Conversions & Scientific Notation

Name: KEY

Block: ____

"Dimension Analysis"

Unit Conversions

A conversion factor is a fraction or factor written so that the denominator and numerator are *equivalent values* with *different units.*

One of the most useful conversion factors allows the user to convert from the metric to the imperial system and vice versa.

Since 1 inch is exactly the same length as 2.54 cm, the factor may be expressed as:

$$\frac{1\ \text{inch}}{2.54\,\text{cm}} \qquad \frac{2.54\,\text{cm}}{1\ \text{inch}}$$

"equivalency statements"

doesn't matter which is on top/bottom. The values are still equal.

These two lengths are identical so multiplication of a given length by the conversion factor will not change the length. It will simply express it in a different unit. $x\,\cancel{\text{cm}} \times \frac{1\ \text{in}}{2.54\,\cancel{\text{cm}}} = \frac{x}{2.54}\ \text{inch}$

Q: Now if you wish to determine how many centimetres are in a yard, you have two things to consider.

1yd.

① First, which of the two forms of the conversion factor will allow you to cancel the imperial unit, converting it to a metric unit?

② Second, what other conversion factors will you need to complete the task?
Assuming you know, or can access, these equivalencies:
1 yard = 3 feet and 1 foot = 12 inches

$\frac{1\ \text{yd}}{3\ \text{ft}}$ or $\boxed{\frac{3\ \text{ft}}{1\ \text{yd.}}}$

$\frac{1\ \text{ft}}{12\ \text{in}}$ or $\frac{12\ \text{in}}{1\ \text{ft.}}$

...your approach would be as follows:

$$1\ \cancel{\text{yd.}} \times \boxed{\frac{3\ \cancel{\text{ft}}}{1\ \cancel{\text{yd.}}}} \times \boxed{\frac{12\ \cancel{\text{in}}}{1\ \cancel{\text{ft}}}} \times \boxed{\frac{2.54\,\text{cm}}{1\ \cancel{\text{in}}}} = \frac{(1)(3)(12)(2.54)}{(1)(1)(1)} = 91.44\,\text{cm}$$

unit to cancel on bottom

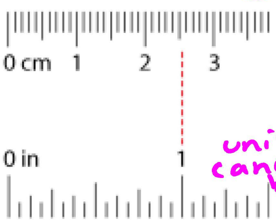


Figure 1.4.2 *A ruler with both imperial and metric scales shows that 1 inch = 2.54 cm.*

Notice that as with the multiplication of any fractions, it is possible to cancel anything that appears on the top AND bottom

We've simply followed a numerator-to-denominator pattern to convert yards to feet to inches to cm.

The number of feet in a yard and inches in a foot are defined values. They are not things we measured. Thus they DO NOT affect the number of significant figures in our answer.

This will be the case for any conversion factors in which the numerator and denominator are in the same system (both metric or both imperial).
As all three of the conversion factors we used are defined value, only the original value of 1.00 yards influences the significant figures in our answer. Hence we round the answer to three sig figs.

measured value.

3 s.f.

Example: How many minutes are there in 3480 seconds?

1 min
60 s

the TOP part
EQUALS
the BOTTOM part

$$\underset{3\,s.f.}{3480\,\cancel{s}} \times \boxed{\frac{1\ \text{min}}{60\ \cancel{s}}} = 58.0\ \text{min}$$

opposite units cancel.

Both 60 s and 1 min are the same length of time. "Equal to", this is the converstion factor.
Multiplying by the converstion facor did not change the VALUE fo the time.
However, the units are different after using the conversion factor:
we started with a LARGE number of *small units* and ended up with a *small number* of LARGE units.

The method of unit conversions uses ***conversion factors*** to change the units associated with an expression to a different set of units.

Every unit conversion problem has three major pieces of information which must be identified:

i) the unknown amount and its **units**
ii) the initial amount and its **units**
iii) a **conversion factor** which relates *(connects)* the initial units to the units of the unknown

INCREDIBLY, VITALLY IMPORTANT NOTE!

In all the calculations which follow you must **ALWAYS** include the units, for they are the "major players" in the calculation. If you are tempted to omit or "forget about" the units, DON'T! The course you fail could be Chem 11!

Example: If a car can go 80 km in 1 h, how far can the car go in 8.5 h?

80 km in 1 h — how far (km) — 8.5 h

CONVERSION STATEMENT (equivalence) — UNKNOWN AMOUNT — INITIAL AMOUNT

Conversion factors:

$$\frac{80\,\text{km}}{1\,\text{hr}} \quad \text{or} \quad \frac{1\,\text{hr}}{80\,\text{km}}$$

$$\frac{8.5\,\cancel{h}}{1} \times \boxed{\frac{80\,\text{km}}{1\,\cancel{h}}} = \frac{680\ \text{km}}{?}$$

Example: If 0.200 mL of gold has a mass of 3.86 g, what is the mass of 5.00 mL of gold?

0.200 mL has a mass 3.86 g — what is the mass? (g) — 5.00 mL

CONVERSION STATEMENT — UNKNOWN AMOUNT — INITIAL AMOUNT

$$\frac{0.200\,\text{mL}}{3.86\,\text{g}} \quad \text{or} \quad \frac{3.86\,\text{g}}{0.200\,\text{mL}}$$

$$5.00\,\cancel{\text{mL}} \times \boxed{\frac{3.86\,\text{g}}{0.200\,\cancel{\text{mL}}}} = 96.5\ \text{g}$$

Example: If 0.200 mL of gold has a mass of 3.86 g, what is the volume occupied by 100.0 g of gold?

same as above — what volume? (mL) — 100.0 g

CONVERSION STATEMENT — UNKNOWN AMOUNT — INITIAL AMOUNT

$$\frac{0.200\,\text{mL}}{3.86\,\text{g}} \quad \text{or} \quad \frac{3.86\,\text{g}}{0.200\,\text{mL}}$$

conversion factors.

$$100.0\,\cancel{\text{g}} \times \boxed{\frac{0.200\,\text{mL}}{3.86\,\cancel{\text{g}}}} = 5.18\ \text{mL}$$

units left with

chemistry homework

Assignment #4- Hebden pg 11-14 Questions #1-2
All assignments are to be completed on a separate page with the assignment number & heading. Be sure to show FULL WORKING OUT for all homework.

Multiple Unit Converstions

What happens when there is **more than one** conversion factor involved in a problem?

REMEMBER: your conversion factor must include a fraction where the numerator (top) and denominator (bottom) are ***equivalent values*** with ***different units.***

Example: If eggs are $1.44/doz and if there are 12 eggs/doz, how many individual eggs can be bought for $4.32?

UNKNOWN AMOUNT: how many eggs?

INITIAL AMOUNT: $4.32

CONVERSION FACTORS: $\left(\frac{\$1.44}{1\ doz}\right)$ and $\left(\frac{12\ eggs}{1\ doz}\right)$

OVERALL CONVERSTION REQUIRED:

$$\cancel{\$}4.32 \times \boxed{\frac{1\ \cancel{doz}}{\cancel{\$}1.44}} \times \boxed{\frac{12\ eggs}{1\ \cancel{doz}}} = 36\ eggs = \left[\frac{(\$4.32)(1\ doz)(12\ eggs)}{(\$1.44)(1\ doz)}\right]$$

Example: The gas tank of a Canadian tourist holds 39.4 L of gas. If 1 L is equal to 0.264 gal in the US, and gas is $1.26/gal, how much will it cost to fill up south of the border?

UNKNOWN AMOUNT: how much will it cost?

INITIAL AMOUNT: 39.4L

CONVERSTION FACTORS: $\left(\frac{1\ L}{0.264\ gal}\right)$ and $\frac{\$1.26}{1\ gal}$

Flip

OVERALL CONVERSTION REQUIRED:

$$39.4\ L \times \boxed{\frac{0.264\ gal}{1\ L}} \times \boxed{\frac{\$1.26}{1\ gal}} = \$13.11$$

chemistry homework

Assignment #5- Hebden pg 15-16 Questions #3-8
All assignments are to be completed on a separate page with the assignment number & heading. Be sure to show FULL WORKING OUT for all homework.

Converting Within the Metric System

Measures	Unit Name	Symbol
length	metre	m
mass	gram	g
volume	litre	L
time	second	s

The metric system is based on powers of 10.
The power of 10 is indicated by a simple prefix. Table 1.4.1 is a list of SI prefixes.
You will need to memorize from "nano" 10^{-9} to "giga" 10^{9}.

You should highlight these.

eg. g → kg
μL → L

Metric conversions require either one or two steps. You will recognize a one-step metric conversion by the presence of a base unit in the question.

The common base units in the metric system include: m, g, L and s.

SOME IMPORTANT EQUIVALENCES

$1\ mL = 1\ cm^3$
$1\ m^3 = 10^3\ L$
$1\ t = 10^3\ kg$

Example: re-write 5 kilograms using PREFIX and UNIT SYMBOLS and the correct EXPONENTIAL EQUIVALENT

Prefix = kilo
unitsymbol = k
exp. equivalent = 10^3

prefix → exp.

5 kilograms $= 5 \times 10^3$ g
5 kg $= 5 \times 10^3$ g $= 500$

base unit

Table 1.4.1 *SI Prefixes*

Prefix	Symbol	10^n
yotta	Y	10^{24}
zetta	Z	10^{21}
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deca	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	µ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}
zepto	z	10^{-21}
yocto	y	10^{-24}

KNOW THESE!

Example: re-write 2.7×10^{-2} m using WRITTEN PREFIX and UNIT and the correct PREFIX SYMBOL

exp → prefix

2.7×10^{-2} m $= 2.7$ c m

base unit

PRACTICE

11. Re-write the following using PREFIX and UNIT SYMBOLS, and EXPONENTIAL EQUIVALENTS.
(a) 2.5 centimetres (c) 25.2 millimoles (e) 0.25 megalitres
(b) 1.3 kilograms (d) 5.1 decigrams (f) 6.38 micrograms

a) 2.5×10^{-2} m c) 25.2×10^{-3} mol e) 0.25×10^{6} L
b) 1.3×10^{3} g d) 5.1×10^{-1} g f) 6.38×10^{-6} g

12. Re-write the following using WRITTEN PREFIXES and UNITS, and EXPONENTIAL EQUIVALENTS.
(a) 2.5 mm base unit (c) 1.9 kmol "mol" (e) 9.94 cg
(b) 6.5 dL (d) 4 Mt (f) 1.25 µs

a) 2.5×10^{-3} m c) 1.9×10^{3} mol e) 9.94×10^{-2} g
b) 6.5×10^{-1} L d) 4×10^{6} t f) 1.25×10^{-6} s

13. Re-write the following using PREFIX SYMBOLS, and WRITTEN PREFIXES and UNITS.
(a) 4.5×10^{-3} mol (c) 0.50×10^{-6} L (e) 8.85×10^{6} t
(b) 1.6×10^{3} m (d) 2.68×10^{-1} g (f) 7.25×10^{-2} m

a) 4.5 mmol c) 0.50 µL e) 8.85 Mt
b) 1.6 km d) 2.68 dg f) 7.25 cm

One & Two-Step Converstions

One step metric conversions involve a base unit (metres, litres, grams, or seconds) being converted to a prefix unit or a prefixed unit being converted to a base unit.

eg. m → μm or mm → m

Metric conversions involve using unit conversions between prefix symbols and exponential equivalents.

exponent ALWAYS goes with the BASE

10^{-2} cm = 1 m

0.01 cm ≠ 1 m

1 cm = 10^{-2} m

$\boxed{1\text{ cm} = 0.01\text{ m}}$

EXAMPLES: (a) Write a conversion statement between **cm** and **m**.

Since "c" stands for "10^{-2}", then $\boxed{1}$ cm = $\boxed{10^{-2}}$ m.

"1 always with prefix"

(b) Write a conversion statement between **ms** and **s**.

Since "m" stands for "10^{-3}" then $\underbrace{1\text{ ms} = 10^{-3}\text{ s}}$.

$\frac{1\text{ ms}}{10^{-3}\text{ s}}$ or $\frac{10^{-3}\text{ s}}{1\text{ ms}}$

Sample Problems — One-Step Metric Conversions

1. Convert 9.4 nm into m.

What to Think about

1. In any metric conversion, you must decide whether you need one step or two. There is a base unit in the question and only one prefix. This problem requires only one step. Set the units up to convert nm into m.
   Let the units lead you through the problem. You are given 9.4 nm, so the conversion factor must have nm in the denominator so it will cancel.

2. Now determine the value of nano and fill it in appropriately. **1** nm = **10**$^{-9}$ m
   Give the answer with the appropriate number of significant figures and the correct unit.
   Because the conversion factor is a defined equality, only the given value affects the number of sig figs in the answer.

How to Do It

9.4 nm

prefix = "nano" = 10^{-9}

conversion factor = 1 nm = 10^{-9} m

1 always w prefix

exponent always w the base unit.

$\frac{1\text{ nm}}{10^{-9}\text{ m}}$ or $\frac{10^{-9}\text{ m}}{1\text{ nm}}$

$9.4\,\cancel{\text{nm}} \times \boxed{\frac{10^{-9}\text{ m}}{1\,\cancel{\text{nm}}}} = \boxed{9.4\times10^{-9}\text{ m}}$

cancel units

Two-step metric conversions require the use of 2 conversion factors. *and exponent rules!

Two factors will be required any time there are 2 prefix units in the question.

In a two-step metric conversion, you must ***always*** convert to the BASE UNIT FIRST!!

2STEP CONVERSIONS

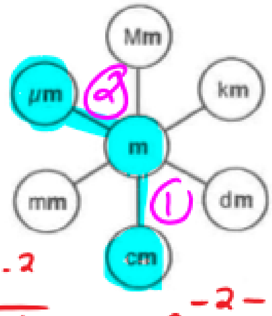
Exponent Rules:

1. $\frac{x^A}{x^B} = x^{A-B}$
2. $(x^A)(x^B) = x^{A+B}$
3. $\frac{(x^A)(x^B)}{(x^C)} = x^{(A+B)-C}$

$\underbrace{A - (-B)}$

$A + B$

This diagram *(right)* shows how a given base unit is related to the important prefix symbols.



want to convert to

$\underline{?}\ \mu m$

Example: How many micrometres are there in 5 cm ?

$$5\,\cancel{cm} \times \boxed{\frac{10^{-2}\,\cancel{m}}{1\,\cancel{cm}}} \times \boxed{\frac{1\,\mu m}{10^{-6}\,\cancel{m}}} = 5\times10^{4}\,\mu m$$

want to cancel

$$\frac{10^{-2}}{10^{-6}} = 10^{-2-(-6)=4}$$

Sample Problems — Two-Step Metric Conversions

1. Convert 6.32 μm into km.

$\mu m \rightarrow m \rightarrow km$

10^{-6} $\quad$ 10^{3}

What to Think about	How to Do It
1. This problem presents with two prefixes so there must be two steps. The first step in such a problem is always to convert to the base unit. Set up the units to convert from μm to m and then to km. 2. Insert the values for 1 μm and 1 km. 1 μm = 10^{-6} m 1 km = 10^{3} m 3. Give the answer with the correct number of significant figures and the correct unit.	exp. with base! $6.32\,\mu m \times \boxed{\frac{10^{-6}\,m}{1\,\mu m}} \times \boxed{\frac{1\,km}{10^{3}\,m}} = 6.32\times10^{-9}\,km$ 1 always with the prefix! $\frac{10^{-6}}{10^{3}} = 10^{-6-3=-9}$

Practice Problems — One- and Two-Step Metric Conversions

1. Convert 16 s into ks. $\frac{16\,s}{1} \times \frac{1\,ks}{10^{3}\,s} = 16\times10^{-3}\,ks$
2. Convert 75 000 mL into L. $75\,000\,mL \times \frac{10^{-3}\,L}{1\,mL} = 75000\times10^{-3}\,L = 75\,L$
3. Convert 457 ks into ms. $457\,ks \times \frac{10^{3}\,s}{1\,ks} \times \frac{1\,ms}{10^{-3}\,s} = 457\times10^{6}\,ms$ (or $4.57\times10^{8}\,ms$)
4. Convert 5.6×10^{-4} Mm into dm. $5.6\times10^{-4}\,Mm \times \frac{10^{6}\,m}{1\,Mm} \times \frac{1\,dm}{10^{-1}\,m} = 5.6\times10^{3}\,dm$

$$\frac{(10^{-4})(10^{6})}{10^{-1}} = 10^{(-4+6)-(-1)=3}$$

Assignment #6- Hebden pg 19-21 Questions #15-17

All assignments are to be completed on a separate page with the assignment number & heading. Be sure to show FULL WORKING OUT for all homework.

Derived Unit Conversions

A **derived unit** is composed of more than one unit. eg. velocity = $\frac{m}{s}$

Units like those used to express rate (km/h) or density (g/mL) are good examples of derived units.

EXAMPLE: The heat change occurring when the temperature of a water sample increases is given by

$$\Delta H = c \cdot m \cdot \Delta T$$

change in heat

change in temp (°C)

mass(g)

"specific heat capacity" (derived unit)

$$c = \frac{\Delta H}{m \cdot \Delta T} = \frac{J}{g \cdot °C}$$ multiple units

Therefore, **c**, is a <u>derived unit</u>, having derived units, found by combinding three other quantities (<u>ΔH, m and ΔT</u>) and their units.

PRACTICE *Show **FULL WORKING OUT** on **THIS PAGE** in the space provided below.*

29. Find the derived value and units for

(a) the molar concentration, **c**, using the equation $c = \frac{n}{V}$, $= \frac{0.250\,mol}{0.500\,L} = 0.500 \frac{mol}{L}$

where: $n = 0.250$ mol and $V = 0.500$ L.

(b) the Universal Gas Constant, **R**, using the equation $R = \frac{P \cdot V}{n \cdot T}$,

i) where $P = 1$ atm, $V = 22.4$ L, $n = 1$ mol and $T = 273$ K (K is the temperature on the Kelvin scale.

ii) where $P = 202.6$ kPa, $V = 24.45$ L, $n = 2$ mol and $T = 298$ K.

(c) the entropy change for the boiling of water, ΔS, using the equation $\Delta H = T \cdot \Delta S$, where: $\Delta H = 44.0$ kJ and $T = 373$ K. (Hint: you will have to rearrange the equation first.)

(d) the kinetic energy of hydrogen gas at 0°C, **KE**, using the equation $KE = \frac{1}{2} m \cdot v^2$,

where: $m = 3.35 \times 10^{-27}$ kg and $v = 1692 \frac{m}{s}$.

$\cdot = \times$

b) $R = \frac{P \cdot V}{n \cdot T}$

i) $R = \frac{(1\,atm)(22.4L)}{(1\,mo\,)(273K)} = \boxed{0.0821 \frac{atm \cdot L}{mol \cdot K}}$

ii) $R = \frac{(202.6\,kPa)(24.45L)}{(2\,mol)(298K)} = \boxed{8.31 \frac{kPa \cdot L}{mol \cdot K}}$

Derived unit conversions require cancellation in 2 directions from numerator to denominator as usual AND from denominator to numerator).

Example: Express 5 Mg/mL in kilograms/litre

$\frac{5\ Mg}{mL} \rightarrow g \rightarrow \frac{kg}{L}$

$1\ Mg = 10^6\ g$
$1\ kg = 10^3\ g$
$1\ mL = 10^{-3}\ L$

$$5\ \frac{\cancel{Mg}}{\cancel{mL}} \times \frac{1\ \cancel{mL}}{10^{-3}\ L} \times \frac{10^6\ \cancel{g}}{1\ \cancel{Mg}} \times \frac{1\ kg}{10^3\ \cancel{g}} = 5\times10^6\ \frac{kg}{L}$$

Sample Problem — Derived Unit Conversions

Convert 55.0 km/h into m/s

What to Think about

1. The numerator requires conversion of a prefixed metric unit to a base metric unit. This portion involves one step only and is similar to sample problem one above.
2. The denominator involves a time conversion from hours to minutes to seconds. The denominator conversion usually follows the numerator.
   Always begin by putting all conversion factors in place using *units only*. Now that this has been done, insert the appropriate numerical values for each conversion factor.
3. As always, state the answer with units and ro
   figures (in this case, three).

How to Do It

km → m
h → min → s.

$1\ km = 10^3\ m$
$1\ min = 60\ s$
$60\ min = 1\ hr$

$$55.0\ \frac{\cancel{km}}{\cancel{h}} \times \frac{10^3\ m}{1\ \cancel{km}} \times \frac{1\ \cancel{h}}{60\ \cancel{min}} \times \frac{1\ \cancel{min}}{60\ s} = ?\ \frac{m}{s}$$

$$\frac{(55)(10^3)}{(1)(60)(60)} = \boxed{15.3\ \frac{m}{s}}$$

Practice Problems — Derived Unit Conversions

1. Convert 2.67 g/mL into kg/L. Why has the numerical value remained unchanged?

$$2.67\ \frac{\cancel{g}}{\cancel{mL}} \times \frac{1\ kg}{10^3\ \cancel{g}} \times \frac{1\ \cancel{mL}}{10^{-3}\ L} = \frac{2.67}{(10^3)(10^{-3})} = \boxed{2.67\ \frac{kg}{L}}$$

2. Convert the density of neon gas from 8.9994×10^{-4} mg/mL into kg/L.

$$8.9994\times10^{-4}\ \frac{\cancel{mg}}{\cancel{mL}} \times \frac{10^{-3}\ \cancel{g}}{1\ \cancel{mg}} \times \frac{1\ kg}{10^3\ \cancel{g}} \times \frac{1\ \cancel{mL}}{10^{-3}\ L} = \frac{(8.9994\times10^{-4})(10^{-3})}{(1)(10^3)(10^{-3})} = \frac{8.9994\times10^{-7}}{10^{3+(-3)}}$$

$-4+(-3)$

$$\boxed{= 8.9994\times10^{-7}\ \frac{kg}{L}}$$

3. Convert 35 mi/h (just over the speed limit in a U.S. city) into m/s. (Given: 5280 feet = 1 mile)

$$35\ \frac{mi}{h} \times \frac{5280\ ft}{1\ mi} \times \boxed{\frac{1\ m}{3.28\ ft}} \times \underbrace{\frac{1\ h}{3600\ s}}_{} = \boxed{15.6\ \frac{m}{s}}$$

$$\frac{1\ h}{60\ min} \times \frac{1\ min}{60\ s} = \frac{1}{60\times60} = \frac{1}{3600}$$

Use of a Derived Unit as a Conversion Factor

eg. mass

A quantity expressed with a derived unit may be used to convert a unit that measures one thing into a unit that measures something completely different eg. volume

The most common examples are the use of rate to convert between distance and time and the use of density to convert between mass and volume.

The keys to this type of problem are determining which form of the conversion factor to use and where to start.

derived unit = conversion factor

Example:

Q: Suppose we wish to use the speed of sound (330 m/s) to determine the time (in hours) required for an explosion to be heard 5.0 km away. ← (starting value)

It is always a good idea to begin any conversion problem by considering **what we are trying to find?**

Begin with the end in mind. This allows us to decide where to begin.

Do we start with 5.0 km or 330 m/s?

(length) km → h (time)

First, consider: are you attempting to convert a $\boxed{\text{unit} \rightarrow \text{unit}}$, or a $\boxed{\frac{\text{unit}}{\text{unit}} \rightarrow \frac{\text{unit}}{\text{unit}}}$?

The answer is km → h begin with the single unit: km.

The derived unit will serve as the conversion factor.

$330\frac{m}{s} \Rightarrow \frac{330\,m}{1\,s}$ or $\frac{1\,s}{330\,m}$

Second, which of the two possible forms of the conversion factor will allow conversion of a distance in km into a time in h?

Plan: km → $\frac{m}{s}$ → h

$$5.0\,\cancel{km} \times \frac{10^3\,\cancel{m}}{1\,\cancel{km}} \times \frac{1\,\cancel{s}}{330\,\cancel{m}} \times \frac{1\,\cancel{min}}{60\,\cancel{s}} \times \frac{1\,h}{60\,\cancel{min}} = 4.2\times10^{-3}\,h$$

(0.0042)

length → time

$\left(\frac{1\,h}{3600\,s}\right)$

$\frac{[(5.0)(10^3)]}{[(330)(60)(60)]}$

PRACTICE Use of Density as a Conversion Factor

What is the volume in L of a 15.0 kg piece of zinc metal? (Density of Zn = 7.13 g/mL)

$\frac{7.13\,g}{1\,mL}$ or $\frac{1\,mL}{7.13\,g}$

What to Think about	How to Do It
1. Decide what form of the conversion factor to use: g/mL or the reciprocal, mL/g. Always begin by arranging the factors using *units* only. As the answer will contain one unit, begin with one unit, in this case, kg.	Plan: (1) kg (mass) → (2) density $\boxed{\frac{g}{mL}}$ → (3) L (volume)
2. Insert the appropriate numerical values for each conversion factor. In order to cancel a mass and convert to a volume, use the reciprocal of the density: $\frac{1\text{mL}}{7.13\text{ g}}$	conversion factor; unit we want; $15.0\,\cancel{kg} \times \boxed{\frac{10^3\,\cancel{g}}{1\,\cancel{kg}}} \times \boxed{\frac{1\,\cancel{mL}}{7.13\,\cancel{g}}} \times \boxed{\frac{10^{-3}\,L}{1\,\cancel{mL}}} = 2.10\,L$
3. Calculate the answer with correct unit and number of significant digits.	(mass) → density → (volume)

$\frac{(15)(10^3)(10^{-3})}{(7.13)}$

mass ← density → volume

PRACTICE — Use of Rate and Density as Conversion Factors

1. The density of mercury metal is 13.6 g/mL. What is the mass of 2.5 L?

$2.5\,L \times \frac{1\,mL}{10^{-3}\,L} \times \frac{13.6\,g}{1\,mL} = 34000\,g$ of Mercury.

2. The density of lead is 11.2 g/cm³. The volumes 1 cm³ and 1 mL are exactly equivalent. What is the volume in L of a 16.5 kg piece of lead?

$16.5\,kg \times \frac{1\,g}{10^{3}\,kg} \times \frac{1\,cm^3}{11.2\,g} \times \frac{1\,mL}{1\,cm^3} \times \frac{10^{-3}\,L}{1\,mL} = 1.47\,L$ of Pb

3. The speed of light is 3.0×10^{10} cm/s. Sunlight takes 8.29 min to travel from the photosphere (light-producing region) of the Sun to Earth. How many kilometres is Earth from the Sun?

$8.29\,min \times \frac{60\,s}{1\,min} \times \frac{3.0\times10^{10}\,cm}{1\,s} \times \frac{10^{-2}\,m}{1\,cm} \times \frac{1\,km}{10^{3}\,m} = 1.5\times10^{8}\,km$

Conversions Involving Units with Exponents (Another Kind of Derived Unit)

If a unit is squared or cubed, it may be cancelled in one of two ways.

It may be written more than once to convey that it is being multiplied by itself *or* it may be placed in brackets with the exponent applied to the *number* inside the brackets as well as to the *unit*.

Hence, the use of the equivalency 1 L = 1 dm³ to convert 1 m³ to L might appear in either of these formats:

3 × m

$$1\,m^3 \times \underbrace{\frac{1\,dm}{10^{-1}\,m} \times \frac{1\,dm}{10^{-1}\,m} \times \frac{1\,dm}{10^{-1}\,m}}_{\text{need to cancel 3x the "m"}} \times \frac{1\,L}{1\,dm^3} \quad \text{OR} \quad 1\,m^3 \times \left(\frac{1\,dm}{10^{-1}\,m}\right)^3 \times \frac{1\,L}{1\,dm^3} = 1000\,L$$

conversion factor

unit still cancel.

Sample Problem – Use of Conversion Factors Containing Exponents

Convert 0.35 m³ (cubic metres) into mL. (1 mL = 1 cm³)

$\frac{1\,mL}{1\,cm^3}$ or $\frac{1\,cm^3}{1\,mL}$ } conversion factors.

What to Think about	How to Do It
1. The unit cm must be cancelled three times. Do this by multiplying the conversion factor by itself three times or through the use of brackets.	x3 cm³ $0.35\,m^3 \times \frac{1\,cm}{10^{-2}\,m} \times \frac{1\,cm}{10^{-2}\,m} \times \frac{1\,cm}{10^{-2}\,m} \times \frac{1\,mL}{1\,cm^3} = \frac{0.35}{10^{-6}} = \boxed{0.35\times10^{6}\,mL}$ cancelled m³
2. Once the units have been aligned correctly, insert the appropriate numerical values.	$\boxed{\text{OR}}$
3. Calculate the answer with the correct unit and number of significant figures.	$0.35\,m^3 \times \left(\frac{1\,cm}{10^{-2}\,m}\right)^3 \times \frac{1\,mL}{1\,cm^3} = \boxed{0.35\times10^{6}\,mL}$

PRACTICE — Use of Conversion Factors Containing Exponents

1. Convert 4.3 dm³ into cm³.

$4.3\,dm^3 \times \left(\frac{10^{-1}\,m}{1\,dm}\right)^3 \times \left(\frac{1\,cm}{10^{-2}\,m}\right)^3 = 4.3\times10^{3}\,cm^3$

$\frac{(4.3)(10^{-1})(10^{-1})(10^{-1})}{(10^{-2})(10^{-2})(10^{-2})} = \frac{(4.3)(10^{-3})}{(10^{-6})} = 4.3\times10^{3}$

2. Atmospheric pressure is 14.7 lb/in². Convert this to the metric unit, g/cm². (Given 454 g = 1.00 lb)

$14.7\,\frac{lb}{in^2} \times \frac{1\,in}{2.54\,cm} \times \frac{1\,in}{2.54\,cm} \times \frac{454\,g}{1.00\,lb} = \frac{(14.7)(454)}{(2.54)(2.54)} = \boxed{1034\,\frac{g}{cm^2}}$

3. ~~Convert a density of 8.2 kg/m³ to lb/ft³ using factors provided in this section.~~

Using Scientific Notation

$\boxed{-2.3445} \times \boxed{10^3}$

Mantissa Exponent

Because it deals with atoms, and they are so incredibly small, the study of chemistry is notorious for using very large and very tiny numbers. For example, if you determine the total number of atoms in a sample of matter, the value will be very large. If, on the other hand, you determine an atom's diameter or the mass of an atom, the value will be extremely small. The method of reporting an ordinary, expanded number in scientific notation is very handy for both of these things.

Scientific Notation refers to the method of representing numbers in exponential *form*. Exponential numbers have two parts. Consider the following example:

standard notation → 24 500 becomes 2.45×10^4 in scientific notation

Convention states that the first portion of a value in scientific notation should always be expressed as a number 1 < 10.

— • — — —
2 single place value.

This portion is called the **mantissa** or the decimal portion
The second portion is the base 10 raised to some power.
It is called the **ordinate** or the exponential **portion**.

mantissa → $\underline{2.45} \times 10^4$ and $2.45 \times \underline{10^4}$ ← ordinate

> 1

A Positive exponent in the ordinate indicates a LARGE number in scientific notation, while a negative exponent indicates a small number # < 1

In fact the exponent indicates the number of 10s that must be multiplied together to arrive at the number represented by the scientific notation. If the exponents are negative, the exponent indicates the number of tenths that must be multiplied together to arrive at the number.

In other words, the exponent indicates the number of places the decimal in the mantissa (decimal #) must be moved to correctly arrive at the regular **notation** (also called **standard notation**) version of the number. (expanded)

A Positive *exponent* indicates the number of *places* the decimal must be moved to the RIGHT, while a Negative exponent indicates the number of *places* the decimal must be moved to the Left.

Scientific Notation to Numbers

Scientific Notation involves moving decimals.

1.5×10^4 (+)
$= 1.5\,0\,0\,0$
$= 15\,000$ ✓

Because the exponent is **Positive** 4, move the decimal point 4 places **to the right.**
Add in Zeroes to fill the empty gaps.

5.8×10^{-4} (−)
$= 0\,0\,0\,0\,5.8$
$= 0.00058$ ✓

Because the exponent is a **Negative** 4, move the decimal point 4 places **to the left.**
Add in Zeroes to fill the empty gaps.

PRACTICE

1. Change the following numbers from scientific notation to expanded notation.
   (a) 2.75×10^3 = 2750 (+) exp → decimal right
   (b) 5.143×10^{-2} = 0.05143 (−) exp ← decimal left.
2. Change the following numbers from expanded notation to scientific notation.
   (a) 69 547 = 6.9547×10^4 ← decimal moved 4 places (+) large #
   (b) 0.001 68 = 1.68×10^{-3} ← decimal moved 3 places (−) small #

SCIENTIFIC NOTATION

Regular Notation (RN)- The standard way that we write our numbers.
Ex: Two Hundred and Eight Million is written - 208 000 000

Scientific Notation (SN)- A shorthand way of writing really large or really small numbers. In SN a number is written as the product of two factors.
Ex: 280,000,000 can be written in scientific notation as 2.8×10^8

$$\underbrace{2.8}_{\text{First Factor}} \times \underbrace{10^8}_{\text{Second Factor}}$$

First Factor
A number that is $1 \leq 10$
It may or may not be decimal

eg. 2.8×10^3
2×10^4

Second Factor
Is always a power of 10
The power of the exponent tells you how many places to move the decimal point.
The sign of the exponent (+) or (−) tells you which direction to move it.

Regular Notation → Scientific Notation

(+) If Decimal is moved left. Exponent will be positive.
"Big #" (+) exp.

If Decimal is moved to Right. Exponent will be negative. (−)
"small #" (−) exp.

	Regular Notation	How to Change	Scientific Notation
#>1 ∴ (+) exp	420,000.	Move the decimal after the 4 and before the 2 That is 5 places to the left Multiply 4.2 by 10 to the 5^{th} power	4.2×10^5
	735,000,000.	Move the decimal after the 7 and before the 3 That is 8 places to the left Multiply 7.35 by 10 to the 8^{th} power	7.35×10^8
#<1 ∴ (−) exp.	0.00897	Move the decimal after the 8 and before the 9 That is 3 places to the right Multiply 8.97 by 10 to the -3^{rd} power	8.97×10^{-3}
	0.0000014	Move the decimal after the 1 and before the 4 That is 6 places to the right Multiply 1.4 by 10 to the -6^{th} power	1.4×10^{-6}

⊖ exponent # are small... move decimal to make smaller

Scientific Notation → Regular Notation

If exponent is Negative Move decimal to the left Add zeros where needed.	If exponent is Positive Move decimal to the Right Add zeros where needed.

⊕ exponent ...move the decimal to make the number Larger

Scientific Notation	How to Change	Regular Notation
7.5×10^5	Exponent is positive 5. Move the decimal 5 places to the right	750 000
3.8×10^4	Exponent is positive 4. Move the decimal 4 places to the right	38 000
0.00 4.2×10^{-3}	Exponent is Negative 3. Move the decimal 3 places to the left.	0.0042
0.0000 7.51×10^{-5}	Exponent is Negative 5. Move the decimal 5 places to the left.	0.0000751

> 1

< 1

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Assignment #7- Scientific Notation Practice Questions

Complete the following questions in the space provided.

Change from Regular Notation to Scientific Notation:		Change from Scientific Notation to Regular Notation:	
1.) 45,000	4.5×10^4	1.) 9.46×10^{-6}	.00000946
2.) 9,000,000	9×10^6	2.) 2.5×10^3	2500
3.) 7,450	7.45×10^3	3.) 1.6×10^{-2}	.016
4.) .0000378	3.78×10^{-7}	4.) 4×10^5	400,000
5.) .05	5×10^{-2}	5.) 7.25×10^4	72,500
6.) 670,400	6.704×10^5	6.) 3.2456×10^{-8}	.000000032456
7.) 7,070,000,000	7.070×10^9	7.) 6×10^{-3}	.006
8.) .00000089	8.9×10^{-7}	8.) 9.7×10^7	97,000,000
9.) .18900097	1.8900097×10^{-1}	9.) 5.06×10^{-4}	.000506
10.) 570,000,000	5.7×10^8	10.) 8×10^2	800

ANSWER KEY

SCIENTIFIC NOTATION

CONVERT EACH NUMBER IN SCIENTIFIC NOTATION TO REGULAR NOTATION

If exponent is Negative	If exponent is Positive
Move decimal to the Left Add zeros where needed.	Move decimal to the Right Add zeros where needed.

1. 2.47×10^{-3}	0.0247	7. 4.5×10^{-5}	0.000045
2. 9.3×10^{7}	93,000,000	8. 5.5×10^{5}	550,000
3. 8.5×10^{-5}	0.000085	9. 6.3×10^{-1}	0.63
4. 2.07×10^{6}	2,070,000	10. 1.98×10^{4}	19,800
5. 7×10^{-8}	0.00000007	11. 2.4×10^{-5}	0.000024
6. 3×10^{2}	300	12. 9.2×10^{7}	92,000,000

CONVERT EACH NUMBER IN REGULAR NOTATION TO SCIENTIFIC NOTATION

If Decimal is moved left	If Decimal is moved to Right
Exponent will be positive	Exponent will be negative

1. 0.0024	2.4×10^{-3}	7. 0.0000035	3.5×10^{-6}
2. 5,604	5.604×10^{3}	8. 45,995	4.5995×10^{4}
3. 693.75	6.9375×10^{2}	9. 754.256	7.54256×10^{2}
4. 0.087	8.7×10^{2}	10. 0.0088	8.8×10^{-3}
5. 8,550,000	8.550×10^{-6}	11. 18.907	1.8×10^{1}
6. 12,000,000	1.2×10^{7}	12. 25,009	2.5009×10^{4}

exp $\times 10^x$ EE

Multiplication and Division in Scientific Notation

To multiply two numbers in scientific notation, we *multiply the* decimal #s and state their product multiplied by 10, raised to a power that is the sum of the exponents.

× ADD EXPONENTS

$$(A \times 10^{a}) \times (B \times 10^{b}) = (A \times B) \times 10^{(a+b)}$$

To *divide* two numbers in scientific notation, we divide one mantissa by the other and state their quotient multiplied by 10, raised to a power that is the *difference* between the exponents.

÷ SUB EXPONENTS

$$(A \times 10^{a}) \div (B \times 10^{b}) = (A \div B) \times 10^{(a-b)}$$

Sample Problems — Multiplication and Division Using Scientific Notation

Solve the following problems, expressing the answer in scientific notation.

1. $(2.5 \times 10^3) \times (3.2 \times 10^6) =$
2. $(9.4 \times 10^{-4}) \div (10^{-6}) =$

What to Think about	How to Do It
Question 1	$(2.5 \times 10^3) \times (3.2 \times 10^6)$
1. Find the product of the ~~mantissas~~ dec.#	$(2.5 \cdot 3.2) = 8.0$
2. Raise 10 to the sum of the exponents to determine the ordinate.	$10^{3+6=9}$
3. State the answer as the product of the new mantissa and ordinate.	$\boxed{= 8.0 \times 10^9}$
Question 2	$(9.4 \times 10^{-4}) \div (10^{-6})$
1. Find the quotient of the mantissas. When no mantissa is shown, it is assumed that the mantissa is 1.	$9.4 \div 1 = 9.4$
2. Raise 10 to the difference of the exponents to determine the ordinate.	$10^{-4-(-6)} = 10^{-4+6} = 10^2$
3. State the answer as the product of the mantissa and ordinate.	$\boxed{= 9.4 \times 10^2}$

PRACTICE — Multiplication and Division Using Scientific Notation

Solve the following problems, expressing the answer in scientific notation, *without* using a calculator. Repeat the questions using a calculator and compare your answers. Compare your method of solving with a calculator with that of another student.

1. $(4 \times 10^3) \times (2 \times 10^4) =$ 8×10^7
2. $(9.9 \times 10^5) \div (3.3 \times 10^3) =$ 3.0×10^2
3. $[(3.1 \times 10^{-4}) \times (6.0 \times 10^7)] \div (2.0 \times 10^5) =$ 9.3×10^{-2}

   $(18.6 \times 10^3) \div (2.0 \times 10^5)$
   or
   1.86×10^4
4. $10^9 \div (5.0 \times 10^6) =$ $0.2 \times 10^3 \rightarrow 2.0 \times 10^2$
5. $[(4.5 \times 10^{12}) \div (1.5 \times 10^4)] \times (2.5 \times 10^{-6}) =$ 7.5×10^2

   $(3.0 \times 10^8)(2.5 \times 10^{-6})$

Addition and Subtraction in Scientific Notation

Remember that a number in proper scientific notation will always have a mantissa between 1 and 10. Sometimes it becomes necessary to shift a decimal in order to express a number in ***proper scientific notation***.

(1) The *number of places* shifted by the decimal is indicated by an *equivalent change* in the *value of the exponent*. If the decimal is shifted Left, the *exponent* becomes Larger; (2) shifting the decimal to the Right causes the *exponent* to become smaller.

Another way to remember this is if the *mantissa becomes smaller* following a shift, the *exponent becomes larger*. Consequently, if the *exponent becomes larger*, the *mantissa becomes smaller*. Consider AB.C × 10^x: if the decimal is shifted to change the value of the mantissa by 10^n times, the value of *x* changes $-n$ times.

For example,

A number such as 18 235.0 × 10^2 (1 823 500 in standard notation) requires the decimal to be shifted 4 places to the left to give a mantissa between 1 and 10, that is 1.823 50.
A left shift 4 places, means the exponent in the ordinate becomes 4 numbers larger (from 10^2 to 10^6). 2+4
The correct way to express 18 235.0 × 10^2 in scientific notation is 1.823 50 × 10^6.
Notice the new mantissa is 10^4 *smaller*, so the exponent becomes 4 numbers larger.

PRACTICE

Express each of the given values in proper scientific notation in the second column. Now write each of the given values from the *first* column in expanded form in the third column. Then write each of your answers from the *second* column in expanded form. How do the expanded answers compare?

← left = larger "Key Notation"

	Given Value	Proper Notation	Expanded Form	Expanded Answer
1.	6 014.51 × 10^2 +3	6.01451 × 10^5	601 451	
2.	0.001 6 × 10^7 −3	1.6 × 10^4	16 000	
3.	38 325.3 × 10^{-6}	3.83253 × 10^{-2}	0.0383253	
4.	0.4196 × 10^{-2}	4.196 × 10^{-3}	0.004196	

→ Right = smaller

When adding or subtracting numbers in scientific notation, it is important to realize that we add or subtract only the ~~mantissa~~. *Do not add or subtract the exponents!*
decimal part

Steps for Adding + Subtracting in Scientific Notation

1) *Shift* the decimal to obtain the Same number *for the exponent* in the ordinate of both numbers to be added or subtracted.
2) Sum(+) *or take the difference* (−) *of the* ~~*mantissas*~~. decimal numbers.
3) Convert back to proper scientific notation when finished. (if needed)

Sample Problems — Addition and Subtraction in Scientific Notation

Solve the following problems, expressing the answer in proper scientific notation.

1. $(5.19 \times 10^3) - (3.14 \times 10^2) =$
2. $(2.17 \times 10^{-3}) + (6.40 \times 10^{-5}) =$

Pro Tip

always shift the decimal to make the exponents the same as LARGEST #

What to Think about	How to Do It
Example #1 1. Begin by shifting the decimal of one of the numbers and changing the exponent so that both numbers share the *same exponent*. For consistency, adjust one of the numbers so that *both* numbers have the *larger* of the two ordinates. The goal is for both mantissas to be multiplied by 10^3. This means the exponent in the second number should be increased by one. Increasing the exponent requires the decimal to shift to the left (so the mantissa becomes smaller). 2. Once both ordinates are the same, the mantissas are simply subtracted.	$5.19 \times 10^3 - 3.14 \times 10^?$ Larger=Left want to make "3" $\therefore 0.314 \times 10^3$ $\cancel{5}^{4}.1\cancel{9}^{8}0 \times 10^3$ -0.314×10^3 4.876×10^3 Exponent stays the same. check if # 1<10 ✓ yes.
Example #1 — Alternate Approach 1. It is interesting to note that we could have altered the first number instead. In that case, 5.19×10^3 would have become 51.9×10^2. 2. In this case, the difference results in a number that is not in proper scientific notation as the mantissa is greater than 10. 3. Consequently, a further step is needed to convert the answer back to proper scientific notation. Shifting the decimal one place to the left (mantissa becomes smaller) requires an increase of 1 to the exponent.	
Example # 2 1. As with differences, begin by shifting the decimal of one of the numbers and changing the exponent so both numbers share the same ordinate. The *larger ordinate* in this case is 10^{-3}. 2. Increasing the exponent in the second number from –5 to –3 requires the decimal to be shifted two to the left (make the mantissa smaller). 3. Once the exponents agree, the mantissas are simply summed.	$(2.17 \times 10^{-3}) + (6.40 \times 10^{\cancel{-5}})$ +2 0.0640×10^{-3} 2.17×10^{-3} $+0.0640 \times 10^{-3}$ 2.2340×10^{-3} exponent stays same.

PRACTICE — Addition and Subtraction in Scientific Notation

Solve the following problems, expressing the answer in scientific notation, *without* using a calculator. Repeat the questions using a calculator and compare your answers. Compare your use of the exponential function on the calculator with that of a partner.

*shift decimal to match larger of 2 exponents

1. 8.068×10^{8}
   -4.14×10^{7}
   7.654×10^{8}

2. 6.228×10^{-4}
   $+4.602 \times 10^{-3}$
   5.2248×10^{-3}

3. 49.001×10^{1}
   $+ \quad 10^{-1}$
   49.011×10^{1}
   correct sci. not. → 4.9011×10^{2}

Scientific Notation and Exponents

Occasionally a number in scientific notation will be raised to some power. When such a case arises, it's important to remember when one exponent is raised to the power of another, the exponents are multiplied by one another.

Consider a problem like $(10^3)^2$. $10^{3 \cdot 2} = 10^6$

This is really just $(10 \times 10 \times 10)^2$ or $(10 \times 10 \times 10 \times 10 \times 10 \times 10)$. So we see this is the same as $10^{(3 \times 2)}$ or 10^6.

$$(A \times 10^a)^b = A^b \times 10^{(a \cdot b)}$$

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Assignment #8- Scientific Notation Topic Review

Complete the following questions in the space provided. Be sure to SHOW FULL WORKING OUT!

Topic Review:

Solve the following problems, expressing the answer in scientific notation, *without* the use of a calculator. Repeat the problems with a calculator and compare your answers.

1. $(10^3)^5$
   $10^{3 \cdot 5} = 10^{15}$

2. $(2 \times 10^2)^3$
   $2^3 \times 10^{2 \cdot 3}$
   $= 8 \times 10^6$

3. $(5 \times 10^4)^2$
   $5^2 \times 10^{4 \cdot 2}$
   $= 25 \times 10^8$

4. $(3 \times 10^5)^2 \times (2 \times 10^4)^2$
   $(3^2 \times 10^{5 \cdot 2}) \times (2^2 \times 10^{4 \cdot 2})$
   $(9 \times 10^{10}) \times (4 \times 10^8)$
   $= (9 \cdot 4) \times 10^{10+8} = 36 \times 10^{18}$
   $= 3.6 \times 10^{19}$

5. Convert the following numbers from *scientific* notation to *expanded* notation and vice versa (be sure the scientific notation is expressed correctly).

Scientific Notation	Expanded Notation
3.08×10^4	30 800
9.6×10^2	960
4.75×10^{-3}	0.00 475
4.84×10^{-4}	0.000 484
0.0062×10^5	620

6. Give the product or quotient of each of the following problems (express all answers in proper form scientific notation). Do **not** use a calculator.

(a) (8.0×10^3) x (1.5×10^6) = 1.2×10^{16}

(b) $(1.5 \times 10^4) \div (2.0 \times 10^2)$ = 7.5×10^1 (75)

(c) $(3.5 \times 10^{-2}) \times (6.0 \times 10^5)$ = 2.1×10^4

(d) $(2.6 \times 10^7) \div (6.5 \times 10^{-4})$ = 4.0×10^{16}

7. Give the product or quotient of each of the following problems (express all answers in proper form scientific notation). Do **not** use a calculator.

(a) $(3.5 \times 10^4) \times (3.0 \times 10^5)$ = 1.05×10^{10}

(b) $(7.0 \times 10^6) \div (1.75 \times 10^2)$ = 4.0×10^4

(c) $(2.5 \times 10^{-3}) \times (8.5 \times 10^{-5})$ = 2.13×10^{-7}

(d) $(2.6 \times 10^5) \div (6.5 \times 10^{-2})$ = 4.0×10^6

8. Solve the following problems, expressing the answer in scientific notation, *without* using a calculator. Repeat the questions using a calculator and compare your answers.

(a) $\begin{array}{r} 4.034 \times 10^5 \\ \underline{-2.12 \times 10^4} \end{array}$

3.822×10^5

(b) $\begin{array}{r} 3.114 \times 10^{-6} \\ \underline{+2.301 \times 10^{-5}} \end{array}$

2.612×10^{-5}

(c) $\begin{array}{r} 26.022 \times 10^2 \\ \underline{+7.04 \times 10^{-1}} \end{array}$

2609.9 2.6099×10^3

9. Solve the following problems, expressing the answer in scientific notation, *without* using a calculator. Repeat the questions using a calculator and compare your answers.

(a) $\begin{array}{r} 2.115 \times 10^8 \\ \underline{-1.11 \times 10^7} \end{array}$

2.00×10^8

(b) $\begin{array}{r} 9.332 \times 10^{-3} \\ \underline{+6.903 \times 10^{-4}} \end{array}$

1.0022×10^{-3}

(c) $\begin{array}{r} 68.166 \times 10^2 \\ \underline{+ \quad\quad \times 10^{-1}} \end{array}$

6.1867×10^3

10. Solve each of the following problems *without* a calculator. Express your answer in correct form scientific notation. Repeat the questions using a calculator and compare.

(a) $(10^{-4})^3$ 1.0×10^{-12}

(b) $(4 \times 10^5)^3$ 6.4×10^{16}

(c) $(7 \times 10^9)^2$ 4.9×10^{19}

d. $(10^2)^2 \times (2 \times 10)^3$ 8×10^7

11. Solve each of the following problems *without* a calculator. Express your answer in correct form scientific notation. Repeat the questions using a calculator and compare.

(a) $(6.4 \times 10^{-6} + 2.0 \times 10^{-7}) \div (2 \times 10^6 + 3.1 \times 10^7)$ $= 2.0 \times 10^{-13}$

(b) $\dfrac{3.4 \times 10^{-17} \times 1.5 \times 10^4}{1.5 \times 10^{-4}}$ $= 3.4 \times 10^{-9}$

(c) $(2 \times 10^3)^3 \times [(6.84 \times 10^3) \div (3.42 \times 10^3)]$ $= 1.6 \times 10^{10}$

(d) $\dfrac{(3 \times 10^2)^3 + (4 \times 10^3)^2}{1 \times 10^4}$ $= 7 \times 10^2$