

Scientific & Chemical Fundamentals

Measurement, Conversions & Calculations

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Measurement & Units

SI units & common units in General Chemistry
(Refer to Lab Manual)

- Quantitative vs. Qualitative
- MASS (Chem: gram; SI: kg)
- LENGTH (Chem: cm & others; SI: m)
- TEMPERATURE (Celsius & Kelvin; SI: K)
- VOLUME (Chem: mL; SI: Liter)
- CHEMICAL AMOUNT: Mole (mol)



Units of Measure

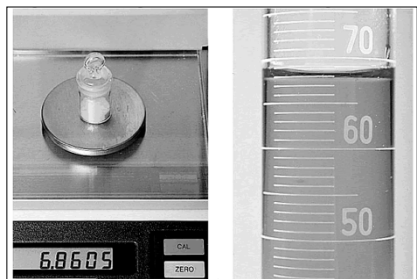
Units	U.S.	SI	Chemistry
Mass (weight)	Pound (lb)	Kilogram (kg)	"Gram" (g, mg)
Volume	Gallon (gal)	Liter (L)	"Liter" (mL, L)
Temperature	Fahrenheit (°F)	Kelvin (K)	K & Celsius (°C)
Length	Mile (mi), Feet(ft), Inches (in)	Meter (m)	"Meter" (cm, mm, nm)
Time		Second (s)	Second (s) Mole (mol)

QUESTION

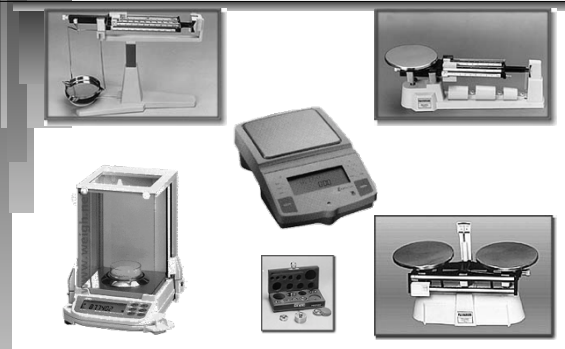
Identify the best match between the dimension or quantity and its correct SI base unit.

	<u>Dimension or Quantity</u>	<u>Unit</u>
A)	Mass	Gram
B)	Length	Kilometer
C)	Time	Minute
D)	Temperature	Celsius
E)	Amount of substance	Mole

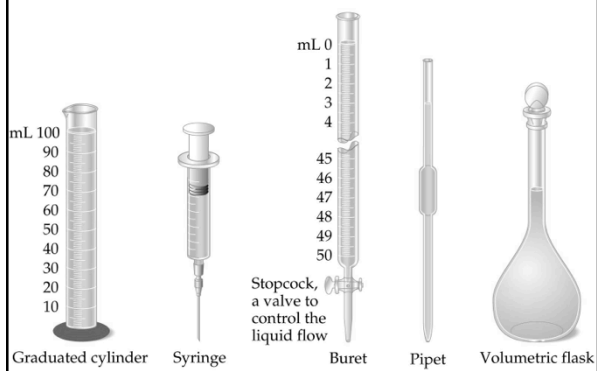
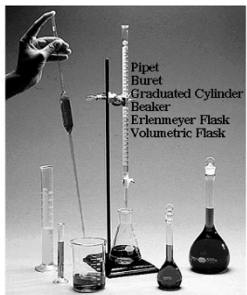
Mass and Volume Measurements: *Refer to Lab Manual*



Mass Determination *(Weighing Devices: Balances)*



Liquid Measurement Tools

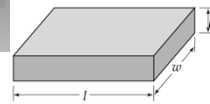


QUESTION

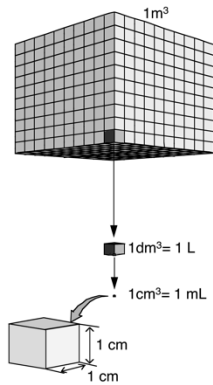
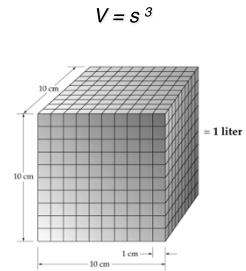
Identify the best match between the dimension or quantity and the unit that is most likely to be measured in Chem 120 lab.

	<u>Dimension or Quantity</u>	<u>Unit</u>
A)	Mass	Kilogram
B)	Length	Meter
C)	Volume	Milliliter
D)	Temperature	Fahrenheit
E)	Amount of substance	Megamole

Volumes of regular shapes



$$V = l \times w \times h$$



Numbers & Measurement

The Importance of Units

Measurement - quantitative observation consisting of 2 parts

- Part 1 - number
- Part 2 - unit

Examples:

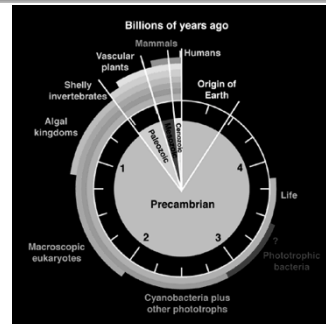
- 20 grams
- 6.63×10^{-34} joules / second

Scale: Size & Comparison

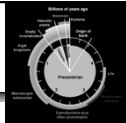
- δ Macroscopic vs. Microscopic
- δ Older IBM financed Video:
Powers of Ten (Movie)
- δ *Powers of Ten (Images)*

How would you compare your lifespan?.. to that of a dog?to the age of the earth?...How about the age of mankind to that of all life?... ..the age of industrialized mankind to the age of mankind?

Graphic Comparisons



QUESTION for Monday



Assume that the earth is 4.6 billion years old and that your Chem 120 class's average lifespan will be 80 years. If the total age of the earth is represented by the face of a clock, how much time will 80 years be represented on the clock?

- A) 1500 microseconds B) 0.75 milliseconds
- C) 8×10^{-4} seconds D) 7.5 megaseconds
- E) 15 gigaseconds

Powers of Ten: Scale

10^n
base number exponent

Powers of 10	
Exponential Number	Ordinary Number
$1 \times 10^6 = 10 \times 10 \times 10 \times 10 \times 10 \times 10$	1,000,000
$1 \times 10^3 = 10 \times 10 \times 10$	1,000
$1 \times 10^2 = 10 \times 10$	100
$1 \times 10^1 = 10$	10
$1 \times 10^0 = 1$	1
$1 \times 10^{-1} = \frac{1}{10}$	0.1
$1 \times 10^{-2} = \frac{1}{10} \times \frac{1}{10}$	0.01
$1 \times 10^{-3} = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10}$	0.001
$1 \times 10^{-6} = \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10}$	0.000 001

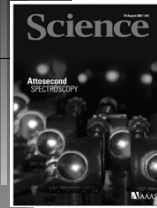
Language describes scale (prefixes)

Shorthand Prefixes

Table: SI prefixes

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

Hella is a prefix associated with Northern California: UC Davis, UC Berkeley, LBL, LLNL & adopted by Google (2010) & Wolfram Alpha (2011)
 "hella-" = 10^{27}



Science, 317, 765-775, (2007)
 "The Electron Stopwatch"

QUESTION

An array of multilayer mirrors compresses ultrabroadband laser pulses (orange beam). The attosecond x-ray pulses allow the real-time observation of atomic-scale electron motion. The previous spectroscopic method was on a femtosecond scale, which was too slow to capture the movement.

How many times faster is attosecond spectroscopy compared to femtosecond methods?

- A. 10x B. 100x C. 1,000x D. 1,000,000x

Commonly used prefixes in Chemistry

These should be known from memory.

Prefix	Symbol	Multiple/Fraction
giga-	G	$1,000,000,000 = 1 \times 10^9$
mega-	M	$1,000,000 = 1 \times 10^6$
kilo-	k	$1,000 = 1 \times 10^3$
Basic unit: meter, gram, liter, second		
deci-	d	$0.1 = 1 \times 10^{-1}$
centi-	c	$0.01 = 1 \times 10^{-2}$
milli-	m	$0.001 = 1 \times 10^{-3}$
micro-	μ	$0.000\ 001 = 1 \times 10^{-6}$
nano-	n	$0.000\ 000\ 001 = 1 \times 10^{-9}$

QUESTION

Select the correct relationship between these metric units of length or distance.

- A) 1 km = 100 m B) 1 mm = 10 cm
 C) 1 nm = 10^9 m D) 10^3 mm = 1 m

QUESTION

Coincidentally, a U.S. nickel has a mass of approximately 5 grams. If you had one dollar's worth of nickels in your jean's what would be the mass of the nickels in milligrams?

- A. 100 milligrams
- B. 50 milligrams
- C. 1,000 milligrams
- D. 100,000 milligrams

$$1000 \text{ milligrams (mg)} = 1 \text{ gram (g)}$$

Scientific Notation & Significant Digits

Scientific Notation: A single digit followed by a decimal and a power of ten.

$$\text{D} . \text{D D} \times 10^n$$

power of 10

significant digits

Examples: 2,345 mL and 0.002340 g

$$2,345 \text{ mL} = 2.345 \times 10^3 \text{ mL} \quad 0.002340 \text{ g} = 2.340 \times 10^{-3} \text{ g}$$

Numbers

- **Expressing a number correctly is determined by the method used in the measurement!**
- **How many numbers should I include?**

Significant Digits (Figures)

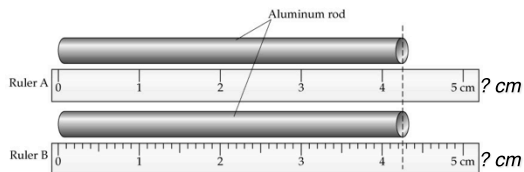
Consider: the exactness of the **measured** value

- **Short Hand expression translates the number: Scientific Notation**



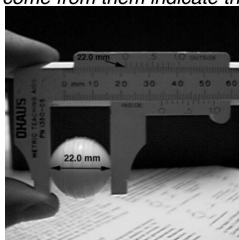
What is the length of the rod?

Different measurement tools give different numbers:
Which ruler is better?



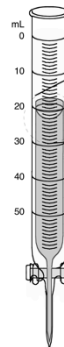
What is the diameter of a circle?

All measuring devices are not the same, and the values (numbers) that come from them indicate their limitations.



Is there a better instrument to use other than a ruler to measure the diameter of the sphere?

Buret



What does each line represent?

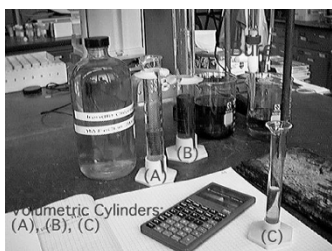
1 mL

What can be estimated?

0.1 mL

Measurement Assignment

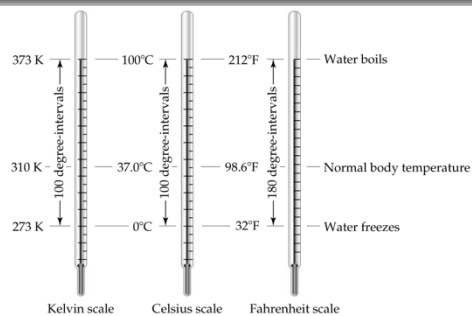
<http://chemconnections.org/general/chem120/volume1.htm>



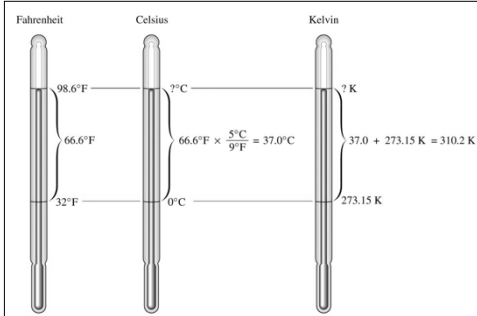
Volumetric Cylinders:
(A), (B), (C)

Temperature Scales

Relative to Water



“Normal” Body Temperature



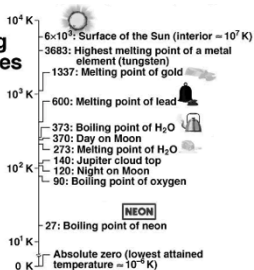
QUESTION

Dr. R. walks into class and claims, “It is very cold in here today. It feels like 242 K.” If that were the temperature, would you agree that you would feel cold? What would that be in Celsius degrees?

- A. I agree, that would be 31°C.
- B. I agree, that would be – 31°C.
- C. I do not agree, that would be 31°C.
- D. I do not agree, that would be 515°C.

Temperature

Some Interesting Temperatures



Reporting Numbers Rules for Significant Digits (Figures)

Nonzero integers always count as significant figures.

3456 g has how many sig figs?

Expressed in scientific notation?

Reporting Numbers Rules for Significant (Digits) Figures

Exact numbers (unit, conversion or scale factors) can have an infinite number of significant figures.

1 liter = 1,000. ml, exactly

1 inch = 2.54 cm, exactly

Zeros

Leading zeros do not count as significant figures.

0.0486 mL has how many sig figs?

• Number expressed in scientific notation?

Zeros

Captive zeros always count as significant figures.

16.07 cm has how many sig figs?

• Number expressed in scientific notation?

Zeros

Trailing zeros are significant only if the number contains a decimal point.

9.300 kg has how many sig figs?

• Number expressed in scientific notation?

QUESTION

In which of these measured values are the zeros not significant figures?

- I) 0.0591 cm
- II) 504 g
- III) 2.70 m
- IV) 5300 L

- A) I and II B) II and III C) I and IV
D) I, III, and IV E) II, III, and IV

QUESTION

Which one of the following does NOT represent four significant digits?

- A. 0.07100 mg
- B. 0.7100 mg
- C. 0.7010 mg
- D. 0.0710 mg

Mathematics & Arithmetic

- Relative to method(s) of measurement
- Short Hand expression: Scientific Notation
- Numbers : How many to include?
Quantitative vs. Qualitative
- Addition/Subtraction.....
- Multiplication/Division.....
- What is "significant"?.....Rounding Off
- <http://www.chemteam.info/SigFigs/SigFigsFable.html>

Systematic Problem Solving

Dimensional/Unit Analysis: Conversions Workshop



How many mL of milk are in a 1/2 gallon carton?

$$\begin{array}{ccc} 0.50 \text{ gal} & \longrightarrow & ? \text{ mL} \\ \downarrow & & \downarrow \\ 1 \text{ gal} = 4 \text{ qt} & \longrightarrow & 1 \text{ qt} = 946 \text{ mL} \\ \hline \frac{0.50 \cancel{\text{gal}} \cdot 4 \cancel{\text{qt}} \cdot 946 \text{ mL}}{1 \cancel{\text{gal}} \cdot 1 \cancel{\text{qt}}} = ? \text{ mL} \end{array}$$

Complete the following Units & Conversions

Number	Scientific Notation	Named unit
13,000,000,000 yrs.	_____	___? <u>gigayears</u>
_____ mL	_____ mL	0.546 Liters 0.546 L
_____ kg	<u>8.45×10^{-1} kg</u>	<u>? grams</u>

Computational Rules

- **Addition/Subtraction:** Answer expressed to the least number of decimal places of the figures in the process
- **Multiplication/Division:** Answer expressed to the least number of significant figures



Addition

- Four students were each asked to measure a piece of wire and provide a total length for the four pieces.
- Report the result correctly:

$$\begin{array}{r}
 0.05 \text{ cm} \\
 12.01 \text{ cm} \\
 1.9 \text{ cm} \\
 + 2.386 \text{ cm} \\
 \hline
 \text{-----}
 \end{array}$$

QUESTION

If you were unloading a 23.50 kg box of books from your car and a "friend" added two more 482 gram chemistry books, how much in kg and using the rules for significant digits, would you be lifting?

- A. 23.98 kg
- B. 24.464 kg
- C. 24.46 kg
- D. 24.5 kg

Mathematical Processes:

- Provide correct answers assuming each value (unit omitted) is written with the correct number of sig figs:

$$\begin{array}{r} 12.01 \quad \times \quad 1.90 \\ \hline 2.386 \end{array} =$$

$$\begin{array}{r} 12.01 \quad \times \quad 1.90 \\ \hline 2.386 \end{array} + 0.05 =$$

QUESTION

The average mass of a certain brand of vitamin C tablets is 253 mg. What is the mass of three such tablets rounded to the proper number of significant digits?

- A. 0.760 grams
- B. 0.759 grams
- C. 0.7590 grams
- D. 0.253 grams

Conversion Factor Method (Dimensional Analysis)

- Qualitative Descriptions vs. Quantitative
- Use exact numbers / "scale factor" UNITS
- A Bookkeeping Method: Example Short"
___ ft ___ in -----> ? m
- (1 ft = 12 in; 2.54 cm = 1 in; 100 cm = 1 m)
- ___ ft x 12 in/ft + ___ in = ___ in
- ___ in x 2.54 cm/in x 1 m/100cm = ___ m

