

CHEMISTRY I NOTES: MEASUREMENT

I. Scientific Measurement

A. can be **qualitative** or **quantitative**

1) **qualitative** —verbal, not numerical, description (rough, bright, red...)

2) **quantitative** —description by numbers (10 lbs., 98.6°, 5'4" tall...)

B. **accuracy**—how close a measurement comes to the true (theoretical) value

C. **precision**—how a measurement can be reproduced (consistent; repeatable)

II. Significant Figures, “Sig.Figs” (also known as Significant Digits, “Sig.Digs”)

A. **significant figures**— all numbers in a measurement that are measured accurately, plus a last estimated digit

B. sig.fig. rules

1) **ALL NONZERO DIGITS ARE ALWAYS SIGNIFICANT.**

4.2 and 27 both have two sig.figs.

2) **ZEROES BETWEEN TWO NONZERO DIGITS ARE ALWAYS SIGNIFICANT.**

ZEROES BETWEEN TWO SIGNIFICANT DIGITS ARE ALWAYS SIGNIFICANT.

(“Sig. Fig. Sandwich”) 8.909 and 1005 both have four sig.figs.

3) **ZEROES TO THE LEFT OF NONZERO DIGITS ARE NOT SIGNIFICANT.**

0.0006 and 0.06 both have only one sig.fig.

4) **TERMINAL ZEROES AFTER THE DECIMAL POINT ARE ALWAYS SIGNIFICANT.**

1.000 and 9.820 both have four sig.figs.

5) **TERMINAL ZEROES NOT INVOLVING A DECIMAL POINT ARE NOT**

SIGNIFICANT... UNLESS WRITTEN IN SCIENTIFIC NOTATION FOR

CLARIFICATION or UNLESS A DECIMAL POINT IS PLACED AFTER THE

LAST ZERO.

1230 written as 1.23×10^3 has three sig.figs.

1230 written as 1230. or 1.230×10^3 has four sig.figs.

C. rounding rules

1) round up if the number after the last sig.fig. is 5 or greater

(48.47 rounded to three sig.figs. is 48.5)

2) round down if the number after the last sig.fig. is less than 5

(140.081 rounded to five sig.figs. is 140.08)

D. sig.fig. addition, subtraction, multiplication, and division rules

1) **IN ADDITION AND SUBTRACTION, THE ANSWER MAY CONTAIN ONLY AS MANY DECIMAL PLACES AS THE LEAST ACCURATE VALUE.**

$5.2208 + 0.1 = 5.3208$

5.3 adjusted

$121.50 + 9000 = 9121.50$

9122 adjusted

2) **IN MULTIPLICATION AND DIVISION, THE ANSWER MAY CONTAIN ONLY AS MANY TOTAL DIGITS AS THE LEAST ACCURATE VALUE USED.**

$5 \times 10.000 = 50.000$

50 adjusted

$49.600 / 47.40 = 1.0464135$

1.046 adjusted

III. SCIENTIFIC NOTATION: $M \times 10^n$ format

A. exponent examples

$10^0 = 1$

$10^1 = 10$

$10^2 = 100$

$10^3 = 1000$

$10^{-1} = 0.1$ (1/10)

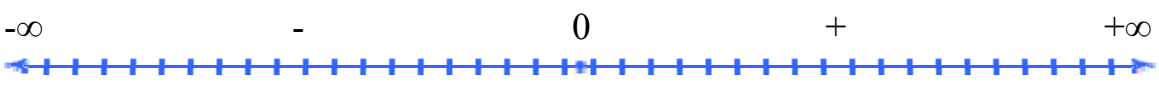
$10^{-2} = 0.01$ (1/100)

$10^{-3} = 0.001$ (1/1000)

B. scientific notation rules

1) **POSITIVE EXPONENTS INDICATE MAKING A NUMBER LARGER. MOVE DECIMAL POINT TO THE RIGHT.**
 $3.11 \times 10^2 = 311$

2) **NEGATIVE EXPONENTS INDICATE MAKING A NUMBER SMALLER. MOVE DECIMAL POINT TO THE LEFT.**
 $3.11 \times 10^{-2} = 0.0311$



IV. THE METRIC SYSTEM (from <http://physics.nist.gov/cuu/>)

A. *The International System of Units* (SI)

- 1) *modern metric system of measurement* established in 1960
- 2) Metric Conversion Act of 1975—formal commitment to encourage metrics in U.S.
- 3) 1978—formal metric use decreed in Europe

B. seven **base units** * = important

<u>SI BASE UNIT</u>	<u>NAME</u>	<u>SYMBOL</u>
length *	meter	m
mass *	kilogram	kg
time *	second	s
temperature *	Kelvin	K
amount of substance *	mole	mol
electric current	ampere	A
luminous (light) intensity	candela	cd

C. **derived units**—complex units formed from the combination of multiple units

<u>Common SI DERIVED UNITS</u>	<u>NAME</u>	<u>SYMBOL</u>
*area	square meter	m^2
*volume	cubic meter	m^3 (L)
		$1L = 1 m^3$ & $1 mL = 1 cm^3 = 1 cc$
*speed	meter per second	m/s
*velocity	meter per second	m/s (with direction)
*acceleration	meter per second squared	m/s^2
*density	kilogram per cubic meter	kg/m^3 (mass/volume)

E. **length**—*linear distance* between two points

- 1) common unit: *meter*, the base unit of linear measure
- 2) common metric units: km, m, cm, mm, μm , nm

F. **volume**—*the 3-D space an object occupies*; a derived unit

- 1) common unit: *liter*—standard volume unit for liquid volume
- 2) common units: cubic meter (m^3), cubic cm (cm^3 or cc), milliliter (mL)
 - $1 L = 1 m^3$ $1 mL = 1 cm^3 = 1 cc$
- 3) liquid volumes can be measured in beakers, graduated cylinders, pipets, syringes, burets, volumetric flasks
- 4) *solid volume = Length x Width x Height (L x W x H)*

G. **mass**—the amount of matter in an object

- 1) *kilogram*—standard unit

2) common metric units: kilogram (kg), gram (g)

- kg = mass of 1 L of water at 4° C
- g = mass of 1 mL of water at 4° C

More metric prefixes

Factor	Name	Symbol
10^{12}	tera	T
10^9	giga	G
10^6	mega	M *
10^3	kilo	k *
10^2	hecto	h *
10^1	deka	da *

Factor	Name	Symbol
10^{-1}	deci	d *
10^{-2}	centi	c *
10^{-3}	milli	m *
10^{-6}	micro	μ *
10^{-9}	nano	n
10^{-12}	pico	p

V. DENSITY (see Ch. 1 for review)

1) **density = mass / volume**

2) **$D = M / V$** $M = D \times V$ $V = M / D$

VI. TEMPERATURE

A. **temperature**—*the measure of the average K.E. (kinetic energy)*

B. “cold” is actually an absence of heat

C. heat transfer—heat energy flow from a higher-temp object to a lower-temp object; occurs when there is contact between the areas/objects

D. temperature scales

1) Celsius (°C)— 0° f.p. H₂O, 100° b.p. H₂O

2) Fahrenheit (°F)— 32° f.p. H₂O, 212° b.p. H₂O

3) Kelvin (K)— 273° f.p. H₂O, 373° b.p. H₂O

- no ° sign used with Kelvin
- **absolute zero**—0 Kelvin; all molecular motion stops
- Kelvin is an absolute scale

4) conversions

$$\mathbf{K = C + 273} \quad ^\circ\text{C} = 5/9 \times (^\circ\text{F} - 32) \quad ^\circ\text{F} = (9/5 \times ^\circ\text{C}) + 32$$

E. examples

EXAMPLE 1: Convert 498 K to Celsius.

$$K = C + 273 \quad C = K - 273 \quad C = 498 - 273 = \boxed{225 \text{ } ^\circ\text{C}}$$

EXAMPLE 2: Convert 37° C to Kelvin.

$$K = C + 273 \quad K = 37 + 273 = \boxed{310 \text{ K}}$$

VII. MEASUREMENT EVALUATION

A. **ERROR** = | accepted value – experimental value| = |(A – E)|

B. **PERCENT ERROR** = $\frac{|A - E|}{A} \times 100$

C. Example:

Dewayne estimated that he had 150 mL of acetic acid in his beaker. When he poured it into a graduated cylinder (which gives more accurate measurements) the volume of liquid was 157.6 mL. What was Dewayne’s percent error?

$$\frac{|A - E|}{A} \times 100 = \frac{|157.6 - 150|}{157.6} \times 100 = \frac{7.6}{157.6} \times 100 = \boxed{4.8\% \text{ error}}$$