Introduction to Chemistry: Measurement

Chapter 1

AP Chemistry

Scientific Notation

- Coefficient is between 1 and 10
- Big numbers have + exponents
- Little numbers have – exponents
- 42 000 = 4.2×10^4
- 0.000 12 = 1.2×10^{-4}

Quantitative Measurements

- SI stands for *International Systems of Units*

Base Quantity	Name of Unit	Symbol
Mass	Kilogram	kg
Length	Meter	m
Time	Second	s or sec
Temperature	Kelvin	K*
Amount of Substance	Mole	mol
Electric Current	Ampere	A
Luminous Intensity	Candela	cd

*** Remember Kelvin = 273.15 + °C**

Metric System Prefixes

Prefix	Meaning
Mega (M_)	$1\ Mm = 1 \times 10^6\ m$
kilo (k_)	$1\ km = 1 \times 10^3\ m$
hecto (h_)	$1\ hm = 1 \times 10^2\ m$
deka (da_)	$1\ dam = 1 \times 10^1\ m$
deci (d_)	$1 \times 10^1\ dm = 1\ m$
centi (c_)	$1 \times 10^2\ cm = 1\ m$
milli (m_)	$1 \times 10^3\ mm = 1\ m$
micro (μ_)	$1 \times 10^6\ \mu m = 1\ m$
nano (n_)	$1 \times 10^9\ nm = 1\ m$
pico (p_)	$1 \times 10^{12}\ pm = 1\ m$

Precision and Accuracy

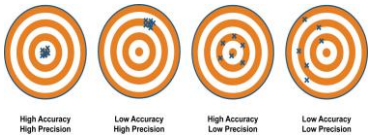
- Precision:

  Hitting the same value over and over. Repeatability.

  More SF.

- Accuracy:

  How close you are to the true value.



Percent Error

- The difference between a theoretical (true value) and the experimental value
- Always expressed as a positive number (absolute value)

$$\%\ \text{Error} = \left| \frac{\text{Theoretical Value} - \text{Experimental Value}}{\text{Theoretical Value}} \right| \times 100$$

Random and Systematic Errors

- Random error—caused by unknown and unpredictable changes in expt
  - Inability to take a measurement in exactly the same way to get the exact same number
- Systematic error—inaccuracies are consistent in the same way
  - Problems persist throughout the expt

- Sources: http://www.math.ttu.edu/~gilliam/ttu/s08/m1300_s08/downloads/errors.pdf, https://www.physics.umd.edu/courses/Phys276/Hill/Information/Notes/ErrorAnalysis.html

Significant Figures

- When dealing with measurements, significant figures become very important
- Significant figures are the meaningful digits in a measured or calculated quantity
- They indicate all of the certain digits plus one digit that is uncertain or estimated
  - Read all values you know for sure + 1 guess

Determining Sig Figs

Rules for Significant Figures

- Any nonzero digit is significant
- Zeros between nonzero digits are always significant
- Zeros at the beginning of nonzero digits are never significant
- Zeros at the end of a number are significant if the number contains a decimal point

Determining Sig Figs

Four Rules

- Any nonzero digit is significant
- Zeros between nonzero digits are always significant
- Zeros at the beginning of nonzero digits are never significant
- Zeros at the end of a number are significant if the number contains a decimal point

Two Rules (Summary)

- No decimal at end: cross out zeroes at end
- Decimal at beginning: cross out zeroes from beginning

Determining Sig Figs

Rules

- Any nonzero digit is significant
- Zeros between nonzero digits are always significant
- Zeros at the beginning of nonzero digits are never significant
- Zeros at the end of a number are significant if the number contains a decimal point

Summary

- No decimal at end: cross out zeroes at end
- 21 000
- 21 000.0

Determining Sig Figs

Rules

- Any nonzero digit is significant
- Zeros between nonzero digits are always significant
- Zeros at the beginning of nonzero digits are never significant
- Zeros at the end of a number are significant if the number contains a decimal point

Summary

- No decimal at end: cross out zeroes at end
- 21 ~~000~~ 2
- 21 000.0 6

Determining Sig Figs

Rules

- Any nonzero digit is significant
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- Zeros at the end of a number are significant if the number contains a decimal point

Summary

- No decimal at end: cross out zeroes at end
- 21 ~~000~~ 2
- 21 000.0 6
- Decimal at beginning: cross out zeroes from beginning
- 0.0021
- 1.0021

Determining Sig Figs

Rules

- Any nonzero digit is significant
- Zeros between nonzero digits are always significant
- Zeros at the beginning of nonzero digits are never significant
- Zeros at the end of a number are significant if the number contains a decimal point

Summary

- No decimal at end: cross out zeroes at end
- 21 ~~000~~ 2
- 21 000.0 6
- Decimal at beginning: cross out zeroes from beginning
- ~~0.00~~21 2
- 1.0021 5

Practice!!!!

Measurement	Number of Sig Figs	Measurement	Number of Sig Figs
25 g		0.12 kg	
0.030 kg		1240560. cm	
1.240560 mg		300000000 m/sec	
60000 sec		6.0×10^6 kg	
246.31 g		4.09×10^3 cm	
20.06 cm		29.200 cm	
1.050 m		0.02500	

Significant Figures with Calculations

- **Addition and Subtraction**
  - The result has the same number of decimal places as the measurement with the **fewest decimal places,** or **least precision**
- **Multiplication and Division**
  - The result contains the same number of significant figures as the measurement with the **fewest significant figures**

Exact numbers

- Keep in mind that exact numbers are obtained from definitions or by counting number of objects and can be considered to have an infinite number of significant figures
- Example:
  If an object has a mass of 0.2786 g then the mass of eight such objects would be…

  0.2786 g x 8 = 2.229 g

Practice!!!!

Calculation	Answer with correct SF	Calculation	Answer with correct SF
3.24 m + 7.0 m		2.6 cm * 3.78 cm	
0.02 cm * 2.371 cm		100.0 g – 23.73 g	
35 cm^2 /0.62 cm		0.02 cm + 2.371 cm	
6.54 m * 0.37 m		0.036 m * 0.0002 m	
713.1 L – 3.872 L		40.8 m^2 / 5.050 m	
39 g / 24.2 g		1800 lb + 3.37 lb	
2.030 mL – 1.870 mL		0.58 dm^3 / 2.15 dm	

Temperature Conversions

Temperature Conversion Factors	
Celsius to Kelvin	K = °C + 273.15
Kelvin to Celsius	°C = K -273.15
Celsius to Fahrenheit	°F = 1.8(°C) + 32
Fahrenheit to Celsius	°C = (°F – 32) /1.8

- Convert 72 °F to °C
- Convert 233 °C to K

Dimensional Analysis

- Conversions, factor-label, etc
- Convert 9.00 in to cm

$$9.00\ \text{in} \times \frac{2.54\ \text{cm}}{1\ \text{in}} = 22.9\ \text{cm}$$

- Convert 45.6 µL (microliters) to ML (megaliters)
- Convert 100 m^3 to cm^3
- Convert 75 miles/hr to m/s