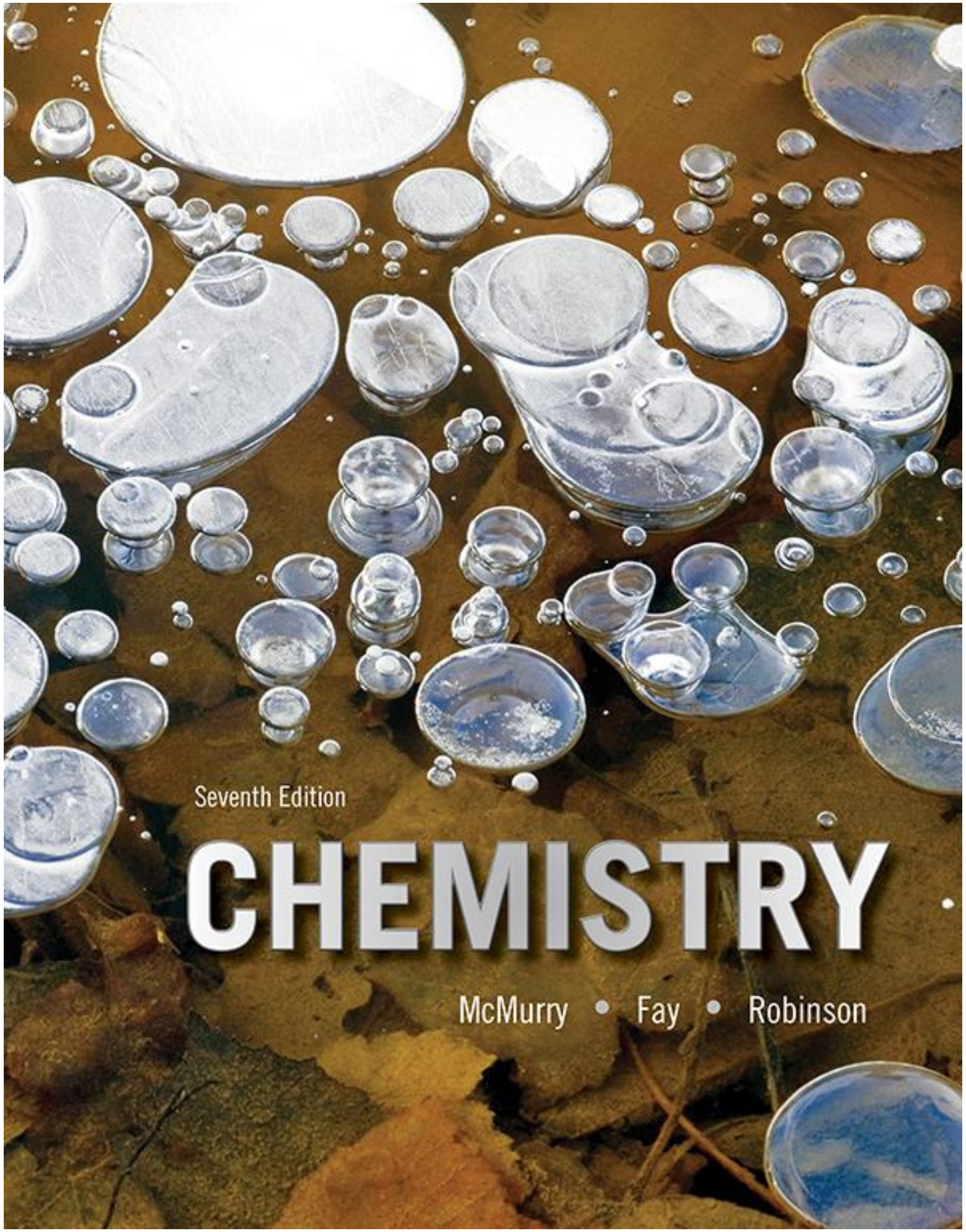


Lecture Presentation

Chapter 1
Chemical Tools: Experimentation and Measurement

HW in textbook for no points on your own: 1.1, 1.3, 1.5, 1.7, 1.15, 1.17, 1.28, 1.58, 1.66, 1.76, 1.82, 1.100 (answers in the back of the book)

John E. McMurry
Robert C. Fay

Instructor's Resource Materials (Download only) for *Chemistry,* 7e
John E. McMurry, Robert C. Fay, Jill Robinson

The Scientific Method

- Observations
  - Recording qualitative or quantitative data
- Hypothesis
  - Explanation of observations
- Experiments
  - Change one variable at a time
  - Test hypothesis
- Theory
  - Explains experiment
  - Predicts further outcome

Scientific Method Example

Observation: Alzheimers is slowed in some people who smoke.

Hypothesis: A substance in cigarette smoke somehow slows Alzheimers in some people. (but increases heart attack, cancer risks)

Experiment: change variable one at a time
-Isolate and identify each component chemicals in cigarette smoke.
-Give each individual component to mice and look for result.
(example: test nicotine effect on Alzheimers)
-Change the molecular structure of cigarette smoke components & look for slowing Alheimers wo increasing heart attack & cancer.

Theory (my speculation) There is a receptor in people with Alzheimers which is blocked by the new molecule analog of component of cigarette smoke. (nicotine is similar in structure to cocaine so not surprising that it would have neurobiological effects)

Experimentation and Measurement

Système Internationale d'Unités

TABLE 1.1 The Seven Fundamental SI Units of Measure

Physical Quantity	Name of Unit	Abbreviation
Mass	kilogram	kg
Length	meter	m
Temperature	kelvin	K
Amount of substance	mole	mol
Time	second	s
Electric current	ampere	A *
Luminous intensity	candela	cd *

All other units are derived from these fundamental units.

Dept. Memorize List: * Not responsible for memorizing (some of this on periodic table card available on quizzes & exams)

TABLE 1.2 Some Prefixes for Multiples of SI Units. The most commonly used prefixes are shown in red.

Factor	Prefix	Symbol	Example
1,000,000,000,000 = 10^{12}	tera	T	1 teragram (Tg) = 10^{12} g
1,000,000,000 = 10^{9}	giga	G	1 gigameter (Gm) = 10^{9} m
1,000,000 = 10^{6}	mega	M	1 megameter (Mm) = 10^{6} m
1000 = 10^{3}	kilo	k	1 kilogram (kg) = 10^{3} g
100 = 10^{2}	hecto	h	1 hectogram (hg) = 100 g
10 = 10^{1}	deka	da	1 dekagram (dag) = 10 g
0.1 = 10^{-1}	deci	d	1 decimeter (dm) = 0.1 m
0.01 = 10^{-2}	centi	c	1 centimeter (cm) = 0.01 m
0.001 = 10^{-3}	milli	m	1 milligram (mg) = 0.001 g
*0.000 001 = 10^{-6}	micro	μ	1 micrometer (μm) = 10^{-6} m
*0.000 000 001 = 10^{-9}	nano	n	1 nanosecond (ns) = 10^{-9} s
*0.000 000 000 001 = 10^{-12}	pico	p	1 picosecond (ps) = 10^{-12} s
*0.000 000 000 000 001 = 10^{-15}	femto	f	1 femtomole (fmol) = 10^{-15} mol

*For very small numbers, it is becoming common in scientific work to leave a thin space every three digits to the right of the decimal point, analogous to the comma placed every three digits to the left of the decimal point in large numbers.

Dept. Memorize List: Memorize those in red (could put on your index card)

Example: conversions & scientific notation

1. Write the following in scientific notation. ($x.xx * 10^x$)

a. 0.000027809

b. 9230734.2

2. Convert 2.789×10^7 meters to kilometers
(10^3 meter = 1 kilometers)

HW: conversions & scientific notation

(Appendix A in textbook p. A-1)

1. Write the following in scientific notation.

a. 4208090.024

b. 0.07130634

End
8/30 F

2. Convert 7.2308×10^2 liters to milliliters
(10^{-3} L = 1 mL)

Mass and Its Measurement

Mass: Amount of matter in an object

Weight: Measures the force with which gravity pulls on an object

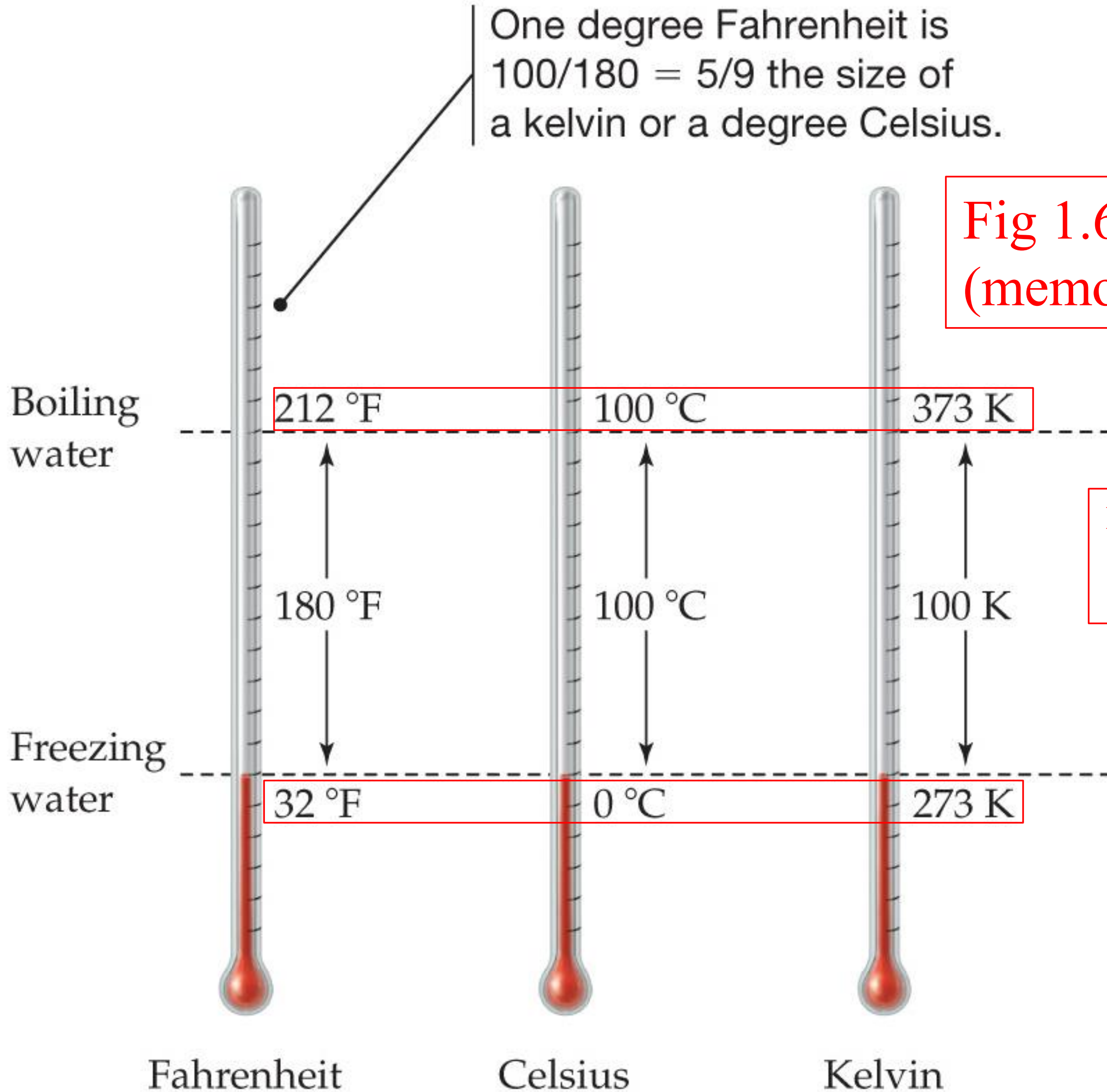


Fig 1.6
(memorize list)

End CHEM 101 D 8/29/19

Temperature and Its Measurement

easiest type of problem: plug into equation

$$°F = \left(\frac{9}{5}\right)°C + 32\ °F$$

$$°C = \left(\frac{5}{9}\right)(°F - 32\ °F)$$

$$K = °C + 273.15$$

Watch those parenthesis in doing math (32 has an infinite # of sig figs while 273.15 only has as many sig figs as shown)

Will need equation – could put on your index card

Temperature and Its Measurement

Convert 25.2 °C to ° F

$$°F = \left(\frac{9}{5}\right)°C + 32 \qquad °F = \left(\frac{9}{5}\right)25.2°C + 32 = 77.4$$

Convert 82.5 °F to ° C HW

End
8/30 G

$$°C = \left(\frac{5}{9}\right)(°F - 32\ °F)$$

Convert 32.5 °C to K HW

$$K = °C + 273.15$$

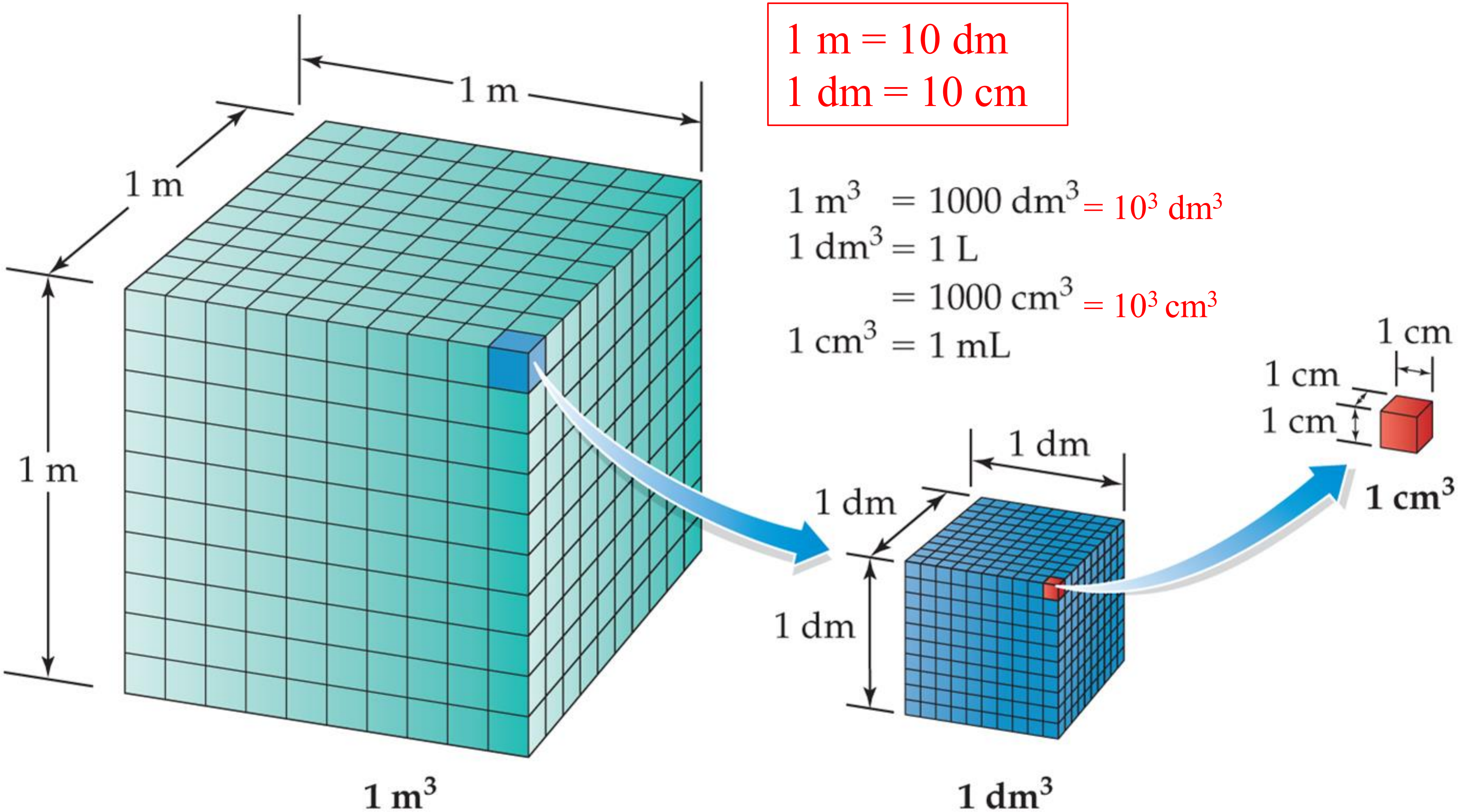
1 m = 10 dm
1 dm = 10 cm

$1\ m^3 = 1000\ dm^3 = 10^3\ dm^3$

$1\ dm^3 = 1\ L$

$= 1000\ cm^3 = 10^3\ cm^3$

$1\ cm^3 = 1\ mL$



Each **cubic meter** contains 1000 **cubic decimeters** (liters).

Each **cubic decimeter** contains 1000 **cubic centimeters** (milliliters).

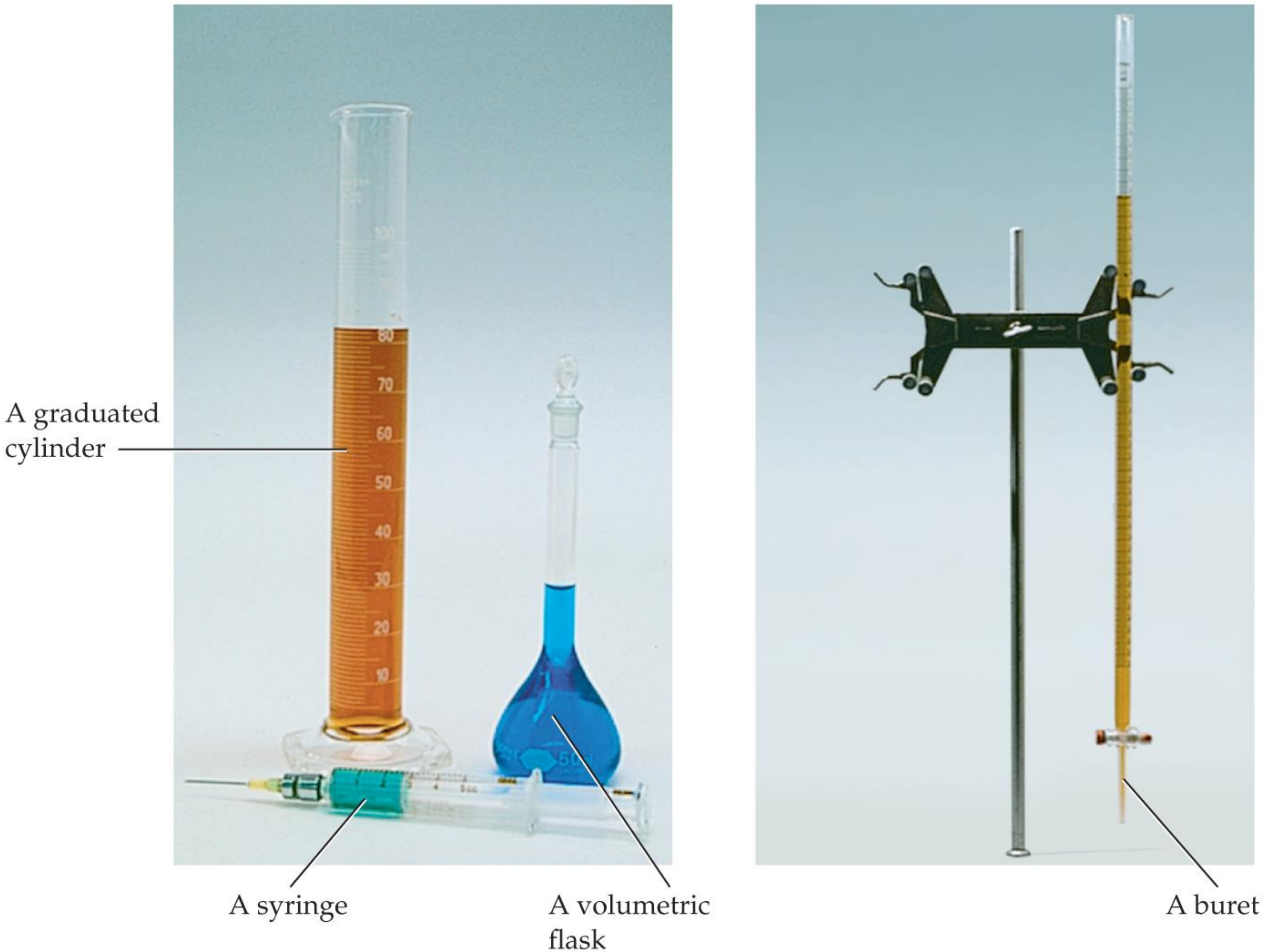
Derived Units: Volume and Its Measurement

TABLE 1.3 Some Derived Quantities

Quantity	Definition	Derived Unit (Name)
Area	Length times length	m^2
Volume	Area times length	m^3
Density	Mass per unit volume	kg/m^3 (more often g/cm^3)
Speed	Distance per unit time	m/s
Acceleration	Change in speed per unit time	m/s^2
Force	Mass times acceleration	$(kg \cdot m)/s^2$ (newton, N)
Pressure	Force per unit area	$kg/(m \cdot s^2)$ (pascal, Pa)
Energy	Force times distance	$(kg \cdot m^2)/s^2$ (joule, J)

On list of memorization: I normally don't make people memorize this. May need at final exam.

Derived Units: Volume and Its Measurement



Derived Units: Density and Its Measurement

TABLE 1.4 Densities of Some Common Materials

Substance	Density (g/cm^3)
Ice (0 °C)	0.917
Water (3.98 °C)	1.0000
Gold	19.31
Helium (25 °C)	0.000 164
Air (25 °C)	0.001 185
Human fat	0.94
Human muscle	1.06
Cork	0.22–0.26
Balsa wood	0.12
Earth	5.54

Typical volume units:
- Solids: cm^3
- Liquids: mL
- Gases: L

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Using Density as a conversion factor (d = mass/volume)

Density of pure water at room temperature is 1.00 g/mL. If I have 250.1 mL of water, how much does it weigh ?

$$250.1\ \text{mL} * \frac{1.00\ \text{g}}{\text{mL}} = 250.1\ \text{grams}$$

Calculations: Converting from One Unit to Another

Dimensional Analysis: A method that uses a conversion factor to convert a quantity expressed in one unit to an equivalent quantity in a different unit

Conversion Factor: Expresses the relationship between two different units

Original quantity × **Conversion factor** = **Equivalent quantity**

Dimensional Analysis: Problem-Solving Strategy - Converting from One Unit to Another

- Can multiply by “one” as many times as you want.

- If (a) is equivalent to (b), then “one” = (a) / (b) OR “one” = (b) / (a). (2.45 cm = 1 inch, conversion factor is either 2.45 cm / 1 inch OR 1 inch /2.45cm)

- Anything in the numerator cancels the same thing in the denominator.

- Always keep the unit of all numbers to help dimensional analysis

Calculations: Converting from One Unit to Another

Relationship: 1 m = 39.37 in.

Conversion Factor: $\frac{1\ \text{m}}{39.37\ \text{in.}}$ or $\frac{39.37\ \text{in.}}{1\ \text{m}}$

Converts in. to m

Converts m to in.

Calculations: Converting from One Unit to Another

$$69.5\ \cancel{\text{in.}} \times \frac{1\ \text{m}}{39.37\ \cancel{\text{in.}}} = 1.77\ \text{m}$$

Starting quantity

Conversion factor

Equivalent quantity

Dimensional Analysis

- A student has entered a 10.0-km run
  - How long is the run in miles?
  - equivalence statements:

1 km = 1000 m

1 m = 1.094 yd

1760 yd = 1 mi

Dimensional Analysis:

$$10.0\ \cancel{\text{km}} \times \frac{1000\ \cancel{\text{m}}}{1\ \cancel{\text{km}}} \times \frac{1.094\ \cancel{\text{yd}}}{1\ \cancel{\text{m}}} \times \frac{1\ \text{mi}}{1760\ \cancel{\text{yd}}} = 6.22\ \text{mi}$$

– 1760 is an exact number

– Since the distance was originally given as 10.0 km, the result can have only three significant figures and should be rounded to 6.22 mi

HW: Dimensional Analysis

The average speed on S. Broad Street is 45.2 miles per hour. What is the speed in cm / second ? Use the conversion factors listed below. (end D, F 9/2/19 M) (G section completed HW)

1 mile = 5280 feet
1 foot = 12 inches
1 inches = 2.54 cm
1 hour = 60 minutes
1 minute = 60 seconds

FOLLOWING SLIDES ARE TO BE COVERED IN LAB CLASS

Accuracy, Precision, and Significant Figures in Measurement

Accuracy: How close to the true value a given measurement is

Precision: How well a number of independent measurements agree with each other

Accuracy, Precision, and Significant Figures in Measurement

Mass of a Tennis Ball
(True mass = 54.441 778 g)

Measurement #	Bathroom Scale	Lab Balance	Analytical Balance
1	0.1 kg	54.4 g	54.4418 g
2	0.0 kg	54.5 g	54.4417 g
3	0.1 kg	54.3 g	54.4418 g
(average)	(0.07 kg)	(54.4 g)	(54.4418 g)

good accuracy
good precision

Accuracy, Precision, and Significant Figures in Measurement

Mass of a Tennis Ball
(True mass = 54.441 778 g)

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(average)	(0.07 kg)	(54.4 g)	(54.4418 g)

good accuracy
poor precision

Accuracy, Precision, and Significant Figures in Measurement

Mass of a Tennis Ball
(True mass = 54.441 778 g)

Measurement #	Bathroom Scale	Lab Balance	Analytical Balance
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2	0.0 kg	54.5 g	54.4417 g
3	0.1 kg	54.3 g	54.4418 g
(average)	(0.07 kg)	(54.4 g)	(54.4418 g)

poor accuracy
poor precision

Accuracy, Precision, and Significant Figures in Measurement

Significant Figures: The total number of digits recorded for a measurement

Generally, the last digit in a reported measurement is uncertain (estimated).

Exact numbers and relationships (7 days in a week, 30 students in a class, etc.) effectively have an

.

Accuracy, Precision, and Significant Figures in Measurement

Rules for Counting Significant Figures (Left-to-Right):

1. Zeros in the middle of a number are like any other digit; they are always significant.

   4.803 cm Four SFs

Accuracy, Precision, and Significant Figures in Measurement

Rules for Counting Significant Figures (Left-to-Right):

1. Zeros in the middle of a number are like any other digit; they are always significant.

2. Zeros at the beginning of a number are not significant (placeholders).

0.006 61 g Three SFs (or 6.61×10^{-3} g)

Accuracy, Precision, and Significant Figures in Measurement

Rules for Counting Significant Figures (Left-to-Right):

1. Zeros in the middle of a number are like any other digit; they are always significant.

2. Zeros at the beginning of a number are not significant (placeholders).

3. Zeros at the end of a number and after the decimal point are always significant.

55.220 K Five SFs

Accuracy, Precision, and Significant Figures in Measurement

Rules for Counting Significant Figures (Left-to-Right):

1. Zeros in the middle of a number are like any other digit; they are always significant.

2. Zeros at the beginning of a number are not significant (placeholders).

3. Zeros at the end of a number and after the decimal point are always significant.

4. Zeros at the end of a number and before the decimal point may or may not be significant.

34,200 m ? SFs

Rounding Numbers

Math Rules for Keeping Track of Significant Figures:

- **Multiplication or Division**: The answer can't have more significant figures than any of the original numbers.

Three SFs ← 278 mi

Four SFs ← 11.70 gal

$$\frac{278\text{ mi}}{11.70\text{ gal}} = 23.760\,684\text{ mi/gal}$$

$$= 23.8\text{ mi/gal}$$

↓

Three SFs

Rounding Numbers

Math Rules for Keeping Track of Significant Figures:

- **Multiplication or Division**: The answer can't have more significant figures than any of the original numbers.

- **Addition or Subtraction**: The answer can't have more digits to the right of the decimal point than any of the original numbers.

3.18	→	Two decimal places
+ 0.01 315	→	Five decimal places
3.19 315		
3.19	→	Two decimal places

Rounding Numbers

Rules for Rounding off Numbers:

1. If the first digit you remove is less than 5, round down by dropping it and all following numbers.

5.664 525 = 5.66

Rounding Numbers

Rules for Rounding off Numbers:

1. If the first digit you remove is less than 5, round down by dropping it and all following numbers.

2. If the first digit you remove is 6 or greater, round up by adding 1 to the digit on the left.

5.664 525 = 5.7

Rounding Numbers

Rules for Rounding off Numbers:

1. If the first digit you remove is less than 5, round down by dropping it and all following numbers.

2. If the first digit you remove is 6 or greater, round up by adding 1 to the digit on the left.

3. If the first digit you remove is 5 and there are more nonzero digits following, round up.

5.664 525 = 5.665

Rounding Numbers

Rules for Rounding off Numbers:

1. If the first digit you remove is less than 5, round down by dropping it and all following numbers.

2. If the first digit you remove is 6 or greater, round up by adding 1 to the digit on the left.

3. If the first digit you remove is 5 and there are more nonzero digits following, round up.

4. If the digit you remove is a 5 with nothing following, round down.

5.664 525 = 5.664 52

END PREVIOUS SLIDES ARE TO BE COVERED IN LAB CLASS