Quiz- Basic Chemistry/Biochemistry
Lecture Notes- The Metric System
Break
Lecture Notes: Exponents, Scientific Notation and the Metric System
Lab 6: The Metric System
Power of 10 Video
Learning Objectives:

1. To know and be able to use the basic SI units of length, volume and mass

2. To execute decimal conversion between basic SI units

3. To understand exponents and practice writing numbers using scientific notation!
NASA's metric confusion caused Mars orbiter loss

*September 30, 1999*
Web posted at: 1:46 p.m. EDT (1746 GMT)

(CNN) -- NASA lost a $125 million Mars orbiter because one engineering team used metric units while another used English units for a key spacecraft operation, according to a review finding released Thursday.

For that reason, information failed to transfer between the Mars Climate Orbiter spacecraft team at Lockheed Martin in Colorado and the mission navigation team in California. Lockheed Martin built the spacecraft.
Origin of the Metric System

WANTED:

A SINGLE, WORLDWIDE, COORDINATED MEASUREMENT SYSTEM

1670 A.D.
Some Background

- Ancient civilizations such as the Egyptians and Babylonians used body parts as references for measurement.
- Although the units were not exactly the same for each person, they worked in a time when measurement was not for mass-produced products.
The Cubit

- The cubit was the first measurement to be “universalized.” It was developed by the Egyptians in 3000 B.C. and measured as the distance from the elbow to fingertip.
- The cubit was the first unit to be standardized by the creation of a standard royal cubit. It was preserved in the form of a black granite rod against which everyone could standardize their own measuring rod.
- Instead of dividing the cubit into smaller units, people instead used other body parts for smaller measures.
Common Historical Units with Origins of Babylonian, Egyptian, Roman, Anglo-Saxon, and Norman-French

- Digit: The breadth of a finger (Egyptian)
- Inch: The width of a man’s thumb
- Foot: The length of a man’s foot
- Span: The length of an outstretched hand from pinkie to thumb
- Hand: Half of a span
- Cubit: Elbow to fingertip (Egyptian)
- Yard: Nose to fingertip
- Fathom: Two yards, length of outstretched arms (Danish)
- Furlong: 220 yards (Anglo-Saxon)
Measurement Development

- The Greeks used many of the same units as the Babylonians and Egyptians because it made trade fair.
- The Romans then adapted the Greek system but did not use the cubit, using the foot as the basis instead.
The Romans used the number 12 as a base for the foot, possibly made official during the reign of Henry I (1100-1135).

It was divided into 12 uniciae, Latin for “inch” and “ounce,” meaning “a twelfth part.”

Dividing the foot into 12 inches provided more opportunities to divide the whole fairly instead of dividing it into ten sections.

Instead of $\frac{1}{2}$, $\frac{1}{5}$, and $\frac{1}{10}$, the foot could be divided into $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{6}$, and $\frac{1}{12}$ for trading purposes.

Longer measurements were done using a pace, equal to five feet.
King Henry I (13th century) stated that the foot would be one-third the length of the yard, and the inch should be one thirty-sixth.

King Edward I standardized the yard by making a permanent measuring stick made of iron. He called it the “iron ulna,” named after the bone of the forearm.

Definitions lasted for almost 600 years.

Queen Elizabeth I changed the Roman mile (5,000 feet = 1,000 paces) to 8 furlongs (5,280 feet).

These standards were then established in the American Colonies.

1793: French government adopted the Metric System.
Interesting Facts(?)

- The word for inch is also the name for “thumb” in many countries.
- The Saxons measured a yard by a sash around their waist. The Saxon word “gird” meant circumference of a person’s waist.
- A pendulum may have been used to standardize the yard. A pendulum that is one yard long makes a complete swing in exactly one second.
1790

- The *National Assembly of France* requested the *French Academy of Sciences* to:

  “deduce an invariable standard for all the measures and all the weights”

- simple and scientific!
Origin of the Metric System

• the unit of length was to be a portion of the Earth's circumference

• volume and mass were to be derived from the unit of length, thus relating the basic units of the system to each other and to nature

• larger and smaller multiples of each unit were to be created by multiplying or dividing the basic units by 10 and its powers
LENGTH: The meter

• derived from the Greek word metron, meaning "a measure"

• the physical standard representing the meter was to be constructed so that it would equal one ten-millionth of the distance from the North Pole to the equator along the meridian running near Dunkirk in France and Barcelona in Spain
WEIGHT: The gram

• the mass of one cubic centimeter of water at its temperature of maximum density
VOLUME: The liter

- the volume of 1 cubic decimeter (a cube 0.1 meter on each side)
The Metric System

- Science uses the metric system of measurement
- Internationally recognized
- Standardized
- It is also the system of measurement used in the medical professions
The Metric System is a Decimal System

- Metric system is based on the decimal system
- That means the divisions are units of 10
- You move the decimal point the proper number of places to the right or left to convert to a larger or smaller division
Units of measurement

- **Mass** is measured in grams \( g \)
- **Length** is measured in meters \( m \)
- **Volume** is measured in liters \( L \)
- **Temp** is measured in Celsius \( C \)
Units of measurement - Prefixes

- Prefixes are added before the basic units of measurement to specify size

<table>
<thead>
<tr>
<th>Unit</th>
<th>Prefix</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>meter</td>
<td>centimeter</td>
<td>cm</td>
<td>1/100&lt;sup&gt;th&lt;/sup&gt; of a meter</td>
</tr>
<tr>
<td>liter</td>
<td>milliliter</td>
<td>mL</td>
<td>1/1000&lt;sup&gt;th&lt;/sup&gt; of a liter</td>
</tr>
<tr>
<td>gram</td>
<td>kilogram</td>
<td>kg</td>
<td>1000 grams</td>
</tr>
</tbody>
</table>
Measuring Temperature

• Temperature is measured in degrees Celsius (°C)
• There are 100 units between the freezing point and the boiling point of water
  – Water freezes at 0 °C
  – Water boils at 100 °C
  – Human body temperature is 37 °C
Conversions within the same metric unit

- Do you want to express the information in a larger or smaller unit?
- If you want to go from a larger to smaller unit you move the decimal point to the right.

e.g. 5.00 m  Convert to cm
      500 cm
Conversions from larger to smaller units

- For each increment of 10 you move the decimal one place to the right
  - If going from kilogram to grams move the decimal 3 places to the right
  - 1 kg = 1000 g
Conversions from smaller to larger units

- Move the decimal point the appropriate number of places to the left
- For each increment of 10 you move the decimal point one place to the left
- Going from centimeter to meter move the decimal point 2 places to the left
- 100 cm = 1 m
Conversion between units

• In the English system it is difficult to change units e.g. from weight to volume

How many pounds does one gallon of water weigh?

1 gallon of water weighs 8.34 pounds
Conversion between units

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  How many pounds does one gallon of water weigh?

  1 gallon of water weighs 8.34 pounds
The innate beauty of the metric system

- The unit of length = meter
- The unit of volume = liter
The innate beauty of the metric system

- The unit of length = meter
- The unit of volume = liter

For water at standard temperature and pressure

\[ 1 \text{ cm}^3 = 1 \text{ cc} = 1 \text{ mL} = 1 \text{ g} \]
The innate beauty of the metric system

- The unit of length = meter
- The unit of volume = liter

For water at standard temperature and pressure:

\[ 1 \text{ cm}^3 = 1 \text{ cc} = 1 \text{ mL} = 1 \text{ g} \]

**QUESTION:**
What is the weight of one liter of water at standard temperature and pressure?
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What is the weight of one liter of water at standard temperature and pressure?

- 1 ml = .001 L
- A liter contains 1000 mL
- 1 mL of water weighs 1 gram
- So a liter of water which contains 1000 mL has a weight of 1000 grams
Review Length
English vs. Metric Units

Which is longer?

A. 1 mile or 1 kilometer
B. 1 yard or 1 meter
C. 1 inch or 1 centimeter

1 inch = 2.54 centimeters
1 yard = 0.9444 meters
1 mile = 1.6 kilometers

Right Image: http://share.lancealan.com/N800%20ruler.jpg
The basic unit of length in the metric system is the meter and is represented by a lowercase m.

Standard: The distance traveled by light in absolute vacuum in \( \frac{1}{299,792,458} \) of a second.

**Metric Units**

1 Kilometer (km) = 1000 meters

1 Meter = 100 Centimeters (cm)

1 Meter = 1000 Millimeters (mm)

**Which is larger?**

A. 1 meter or **105 centimeters**

B. 4 kilometers or **4400 meters**

C. 12 centimeters or **102 millimeters**

D. 1200 millimeters or 1 meter
How many millimeters are in 1 centimeter?

1 centimeter = 10 millimeters

What is the length of the line in centimeters? _______ cm
What is the length of the line in millimeters? _______ mm

What is the length of the line to the nearest centimeter? _______ cm

HINT: Round to the nearest centimeter – no decimals.
Review Mass
English vs. Metric Units

Which is larger?

1. 1 Pound or 100 Grams
2. 1 Kilogram or 1 Pound
3. 1 Ounce or 1000 Milligrams

1 pound = 453.6 grams

1 ounce of gold = 28,349.5 milligrams

100 kilogram = 220 pounds
**Metric Units**

**Mass** refers to the amount of matter in an object.

The base unit of mass in the metric system is the **kilogram** and is represented by **kg**.

Standard: 1 kilogram is equal to the mass of the **International Prototype Kilogram** (IPK), a platinum-iridium cylinder kept by the BIPM at Sèvres, France.

**Metric Units**

1 Kilogram (km) = 1000 Grams (g)

1 Gram (g) = 1000 Milligrams (mg)

**Which is larger?**

A. 1 kilogram or 1500 grams  
B. 1200 milligrams or 1 gram  
C. 12 milligrams or 12 kilograms  
D. 4 kilograms or 4500 grams

Review Volume
Which is larger?

A. 1 liter or 1 gallon

B. 1 liter or 1 quart

C. 1 milliliter or 1 fluid ounce

1 gallon = 3.79 liters

It would take approximately 3 ¾ 1-liter bottles to equal a gallon.

1 fl oz = 29.573 ml

1 12-oz can of soda would equal approximately 355 ml.

1 quart = 0.946 liters
**Volume** is the amount of space an object takes up.

The base unit of volume in the metric system is the **liter** and is represented by **L or l**.

Standard: 1 liter is equal to one cubic **decimeter**

**Metric Units**

1 liter (L) = 1000 milliliters (mL)

1 milliliter (mL) = 1 cm³ (or cc) = 1 gram*

**Which is larger?**

A. 1 liter or **1500 milliliters**

B. 200 milliliters or **1.2 liters**

C. **12 cm³** or 1.2 milliliters*
Measuring Volume

We will be using **graduated cylinders** to find the volume of liquids and other objects.

Read the measurement based on the bottom of the **meniscus** or curve. When using a real cylinder, make sure you are eye-level with the level of the water.

What is the volume of water in the cylinder? _____mL

What causes the meniscus?

A concave meniscus occurs when the molecules of the liquid attract those of the container. The glass attracts the water on the sides.
Measuring Liquid Volume

What is the volume of water in each cylinder?

Pay attention to the scales for each cylinder.
We can measure the volume of regular object using the formula **length x width x height**.

\[ \text{_____ X _____ X _____} = \text{_____} \]

We can measure the volume of irregular object using **water displacement**.

Amount of H\textsubscript{2}O with object = _____

About of H\textsubscript{2}O without object = _____

Difference = Volume = _____
Exponents, Scientific Notation and the Metric System
Lab 6: The Metric System

– Understand the metric system and be able to convert between metric units
– Understand the difference between a milliliter and a microliter
– Learn to correctly use a micropipette
– Define concentration and dilution
– Be able to make a serial dilution
Power of 10 Video
DUE TODAY – Wednesday June 9

1. Hand in Lab 6: Metrics & Measurement
2. Hand in The Metrics Packet

FOR NEXT CLASS – Thursday June 10

1. Read: pp.62-79 (Overview of Cellular Basis of Life to Cellular Membranes)
2. Read bring the following lab worksheet to class:
   Lab 8: Osmosis and Diffusion

REMEMBER: DROP DEADLINE is June 24th