CHEMISTRY, MATTER AND MEASUREMENTS

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III. Required Math Skills
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V. Pure Substances and Mixtures
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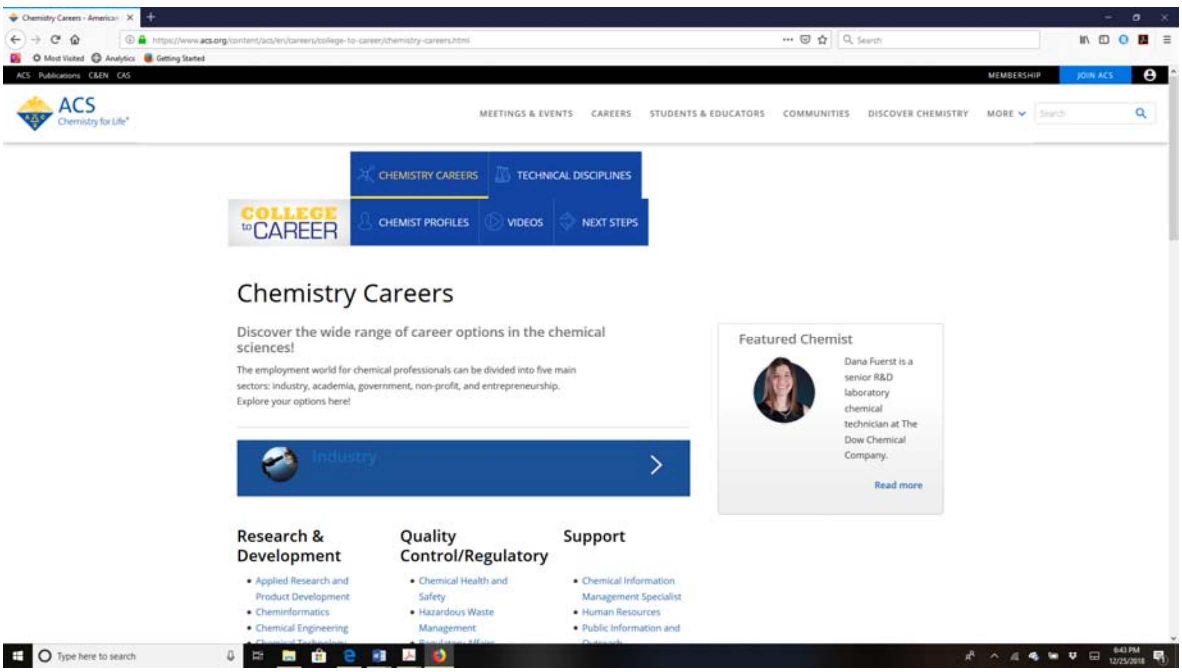
I. Definition of Chemistry

Chemistry is the study of matter, its properties, how and why substances combine or separate to form other substances, and how substances interact with energy. Many people think of chemists as being white-coated scientists mixing strange liquids in a laboratory, but the truth is we are all chemists. Understanding basic chemistry concepts is important for almost every profession. Chemistry is part of everything in our lives.

Every material in existence is made up of matter — even our own bodies. Chemistry is involved in everything we do, from growing and cooking food to cleaning our homes, bodies to launching a space shuttle. Chemistry is one of the physical sciences that help us to describe and explain our world. A chemist can be an entrepreneur, a government scientist, an industry scientist, an educator or a non-traditional career.

For more information please visit: https://www.acs.org/content/acs/en/careers/college-to-career/chemistry-careers.html



[Chapter Objectives](#)

II. Scientific Method

1) Knowledge builds when we start to ask a question about an observed fact. The first step in acquiring scientific knowledge is often the Observation or measurement. Some observations are simple, requiring nothing more than the naked eye. Other observations depend on the use of sensitive instrumentation. Occasionally, an important observation happens entirely by chance. Antoine Lavoisier (1743–1794), a French chemist who studied *combustion*, burned substances in closed containers. He carefully measured the mass of each container and its contents before and after

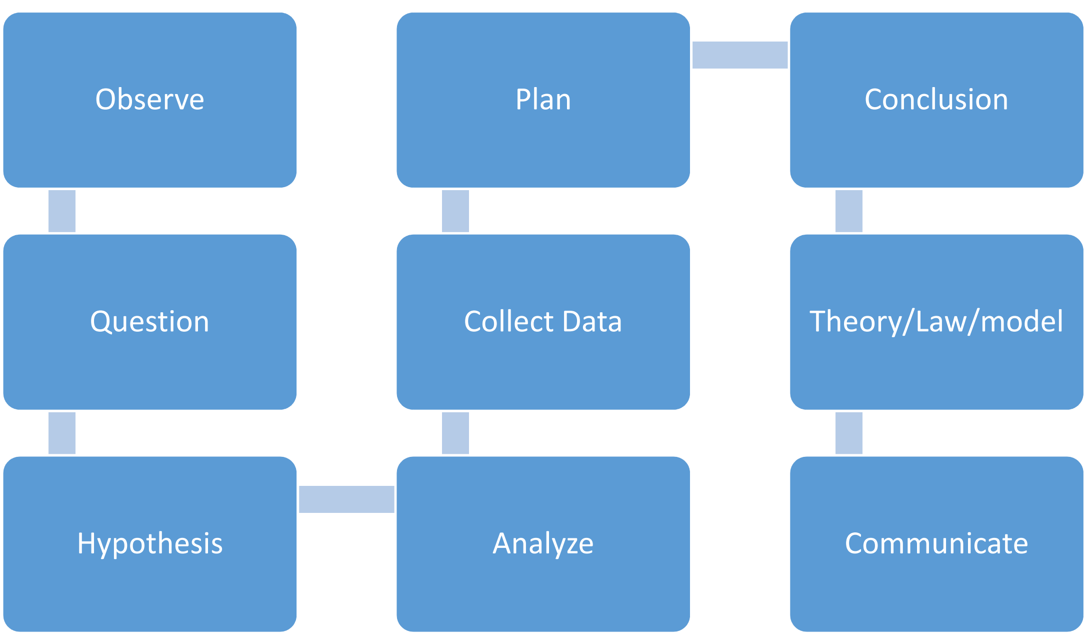
burning the substance inside, and observed that there was no change in the mass during combustion. Lavoisier made an *observation* about the chemical change.

2) Observations are the starting point that lead to hypotheses or laws. Observations often lead scientists to formulate a hypothesis, tentative interpretation or explanation of the observations. Lavoisier explained his observations on combustion by hypothesizing that combustion involved the combination of a substance with a component of air. A good hypothesis is *falsifiable*, which means that further testing has the potential to prove it wrong. Hypotheses are tested by_experiments, highly controlled observations designed to validate or invalidate hypotheses. The results of an experiment may confirm a hypothesis or show the hypothesis to be mistaken in some way. In the latter case, the hypothesis may have to be modified, or even discarded and replaced by an alternative hypothesis. Either way, the new or revised hypothesis should also be tested through further experimentation.

3) Sometimes a number of similar observations lead to the development of a scientific law, a brief statement that summarizes facts based on previous observations and predicts future ones. For example, based on his observations of combustion, Lavoisier developed the law of conservation of mass, which states, “In a chemical reaction matter is neither created nor destroyed.” This statement came out of Lavoisier’s observations, and it predicted the outcome of similar experiments on *any* chemical reaction. Laws are also subject to experiments, which can prove them wrong or validate them.

4) One or more well-established hypotheses may form the basis for a scientific theory. Theories provide a broader and deeper explanation for observations and laws. They are models of the way nature is, and they often predict behavior that extends well beyond the observations and laws on which they are founded. A good example of a theory is the atomic theory of John Dalton (1766–1844). Dalton explained the law of conservation of mass, as well as other laws and observations, by proposing that all matter was composed of small, indestructible particles called atoms. Dalton’s theory was a model of the physical world—Scientific theories are also called *models*
.

5) Theories are also tested and validated by experiments. If a law, hypothesis, or theory is inconsistent with the findings of an experiment, it must be revised and new experiments must be conducted to test the modified hypotheses. Over time, scientists eliminate inconsistent theories, and better theories that are consistent with experiment only remain. Established theories with strong experimental support are the most powerful pieces of scientific knowledge. People unfamiliar with science sometimes say, “That is just a theory,” as if theories were mere imaginations. However, well-tested theories are as close to truth as we get in science.



Chapter Objectives

III. Math skills required in this course

1) Algebra: Algebra is used to solve equations by un-doing whatever is being done to an unknown variable. For example, if an equation has "x+2" then you would subtract "2" to solve for "x". Everything that is done to one side must be done to the other side of the equation as well.
2) Logarithm: logarithms are a way of counting of power of a base number. If $x = \log_b y$ then $y = b^x$. If no base is specified, it's assumed to be 10. A natural log (ln) uses the base of "e" (2.313).
3) Graphical Interpretation: A graph represents the relationship between two variables, either direct, inverse or exponential. A point on the line of the graph indicates the value of one variable with respect to the value of another variable.
4) Calculator tips: Ask your instructor on how to operate your calculator

Questions:

Q#1

1. Where can you find chemicals?

a) In laboratory
b) In grocery or hardware store
c) All around you and inside you
d) All of the above

Q#2

Which statement best defines chemistry?

a) The science that makes shampoo and drugs
b) The science that studies air and water pollution
c) The science that deals with reactions happening in laboratory
d) The science that connects properties of particles that compose matter with how things work in nature
e) All of the above

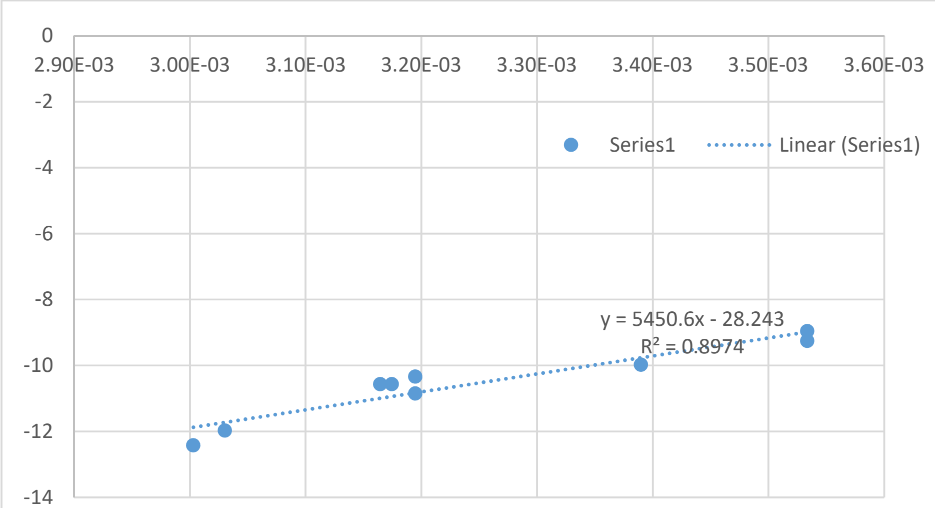
Q#3

According to the scientific method, what is a law?

a) A fact that cannot be changed
b) A model that gives insight to a natural process
c) An initial guess with explanatory power
d) A short statement that summarizes a large number of observations

Q#4

The graph below shows the value of one variable(along Y axis) as a function of its another variable(along X axis). What is the estimated value of Y when the value of X is= 3.2E-03?



A) -8
B) -10
C) -12
D) None of the above

Q#5

Which characteristic is necessary for success in understanding chemistry?

a) Calculation
b) Curiosity
c) Motivation, determination, commitments
d) All of the above

Chapter Objectives

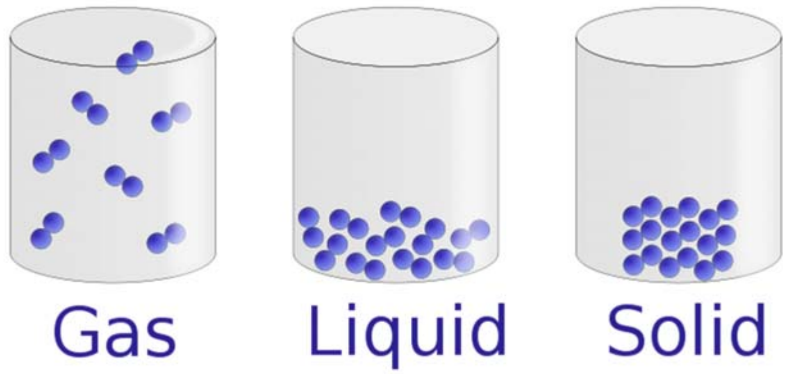
IV. Classification of Matter

Matter is anything that has mass and takes up volume. Chemistry is the study of matter, its composition, properties and transformations. In Chemistry matter is considered at particulate level. Every matter can be seen at macroscopic level as well as microscopic particulate level.

At the particulate level, three states of matter exist. A solid has a definite volume, and maintains its shape and regardless of the container in which it is placed. The particles of a solid lie close together and are arranged in a regular three-dimensional array.
A liquid has a definite volume, but takes on the shape of a container it occupies. The particles of a liquid are close together, but they can randomly move around, sliding past one another.

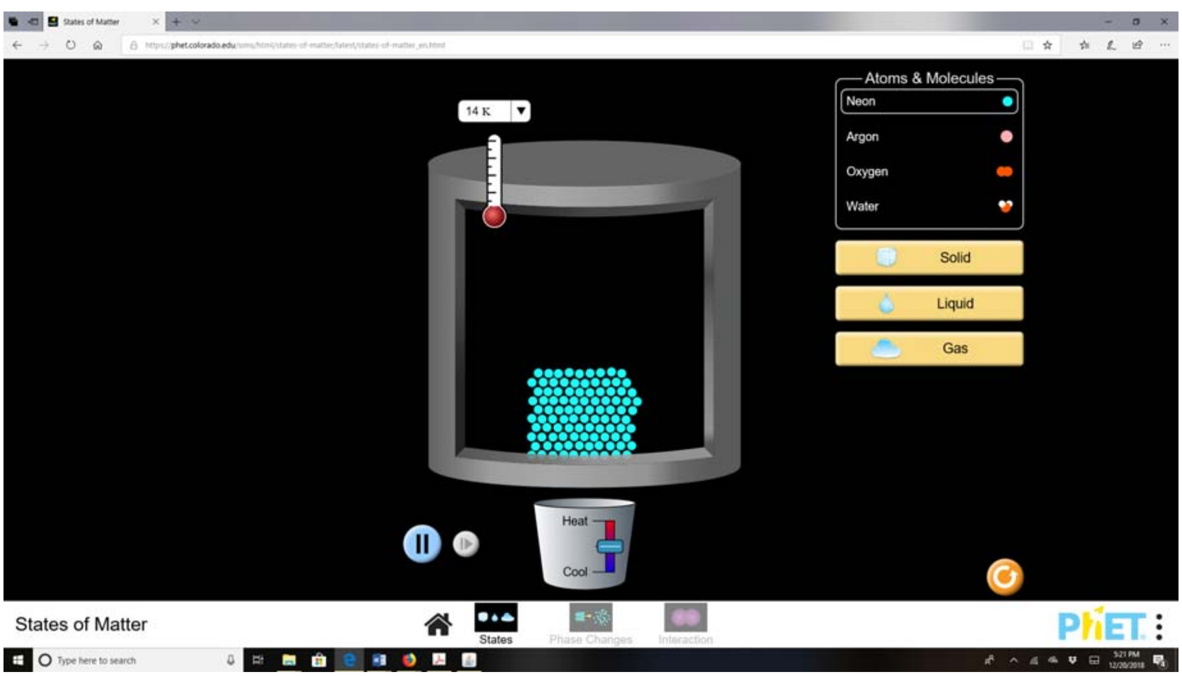
A gas has no definite shape or volume. The particles of a gas move randomly and are separated by a distance much larger than their size. The particles of a gas expand to fill the volume and assume the shape of whatever the container they are put in.

One phase is converted to another phase by the addition of thermal energy.



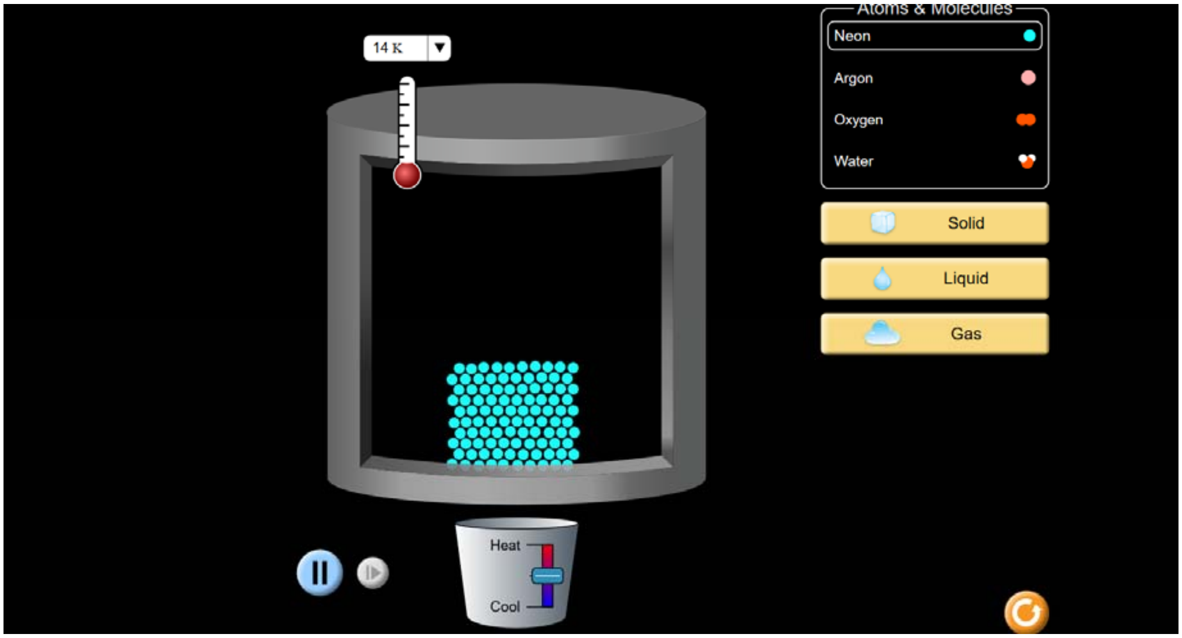
<u>Try this out!</u>

https://phet.colorado.edu/sims/html/states-of-matter/latest/states-of-matter_en.html



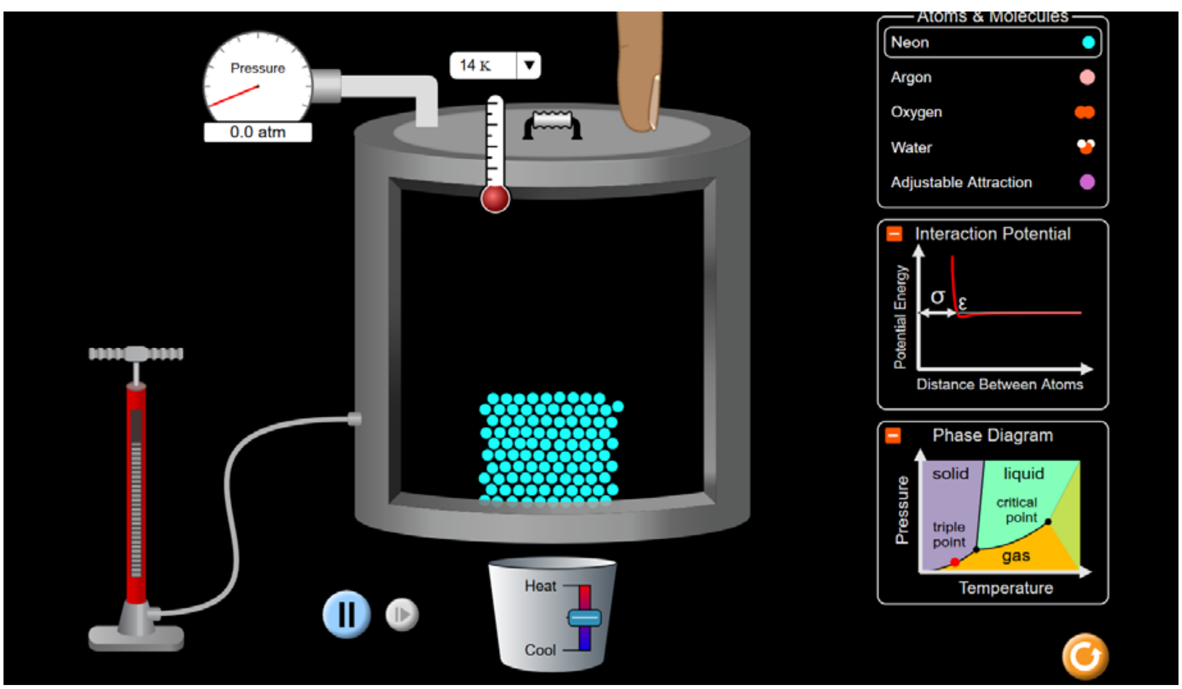
Go to the above PHET simulation activity of states of matter.

1) Click on Neon and observe the motion as solid liquid and gas. What do you notice?
2) Change the substance from Neon to Argon and click on solid, liquid and gas respectively. Both are atoms. What do you observe?
3) Now change to molecules like oxygen and water. What do you observe?
4) What do you observe when you increase or decrease the temperature of solid, liquid and gas?



Now Click on the phase change tab and press the finger to increase the pressure for solid, liquid and gas.

5) Which states of matter can be mostly compressed?
6) What do you conclude about volume and shape of three states of matter from this experiment?



Ans: 1) Solid particles are rigid with little vibration, liquid particles are slightly mobile, gas particles are moving with high speed, colliding with each other.
2) same
3) same
4) kinetic energy decreases with decreasing temp and increases with increasing with temperature
5) Gas
6) With increasing motion

Chapter Objectives

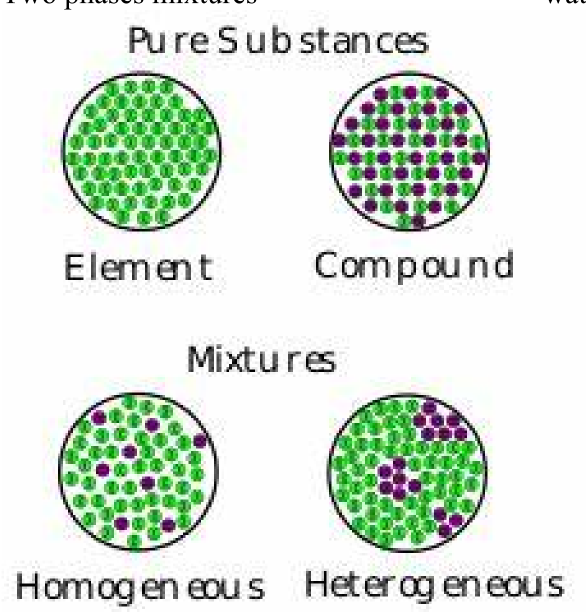
V. Pure substances and mixtures

A pure substance is composed of a single component and has a constant composition, regardless of the sample size and the origin of the sample. Pure substance can be either an element composed of only one identical type of substances or a compound when two or more different elements chemically combined to produce a new substance with own properties and reactions. In both cases they have only one type of particles. Their composition is uniform and and they represent their own characteristics and properties.
.
A mixture is composed of more than one substance physically combined. The composition of a mixture can vary depending on the sample. Components of the mixture can be separated by any physical method. Mixture can be classified in two categories: homogeneous (single phase) and heterogeneous (two difference phases).

Some examples of pure substances: water, aluminum wire, rust etc.
Some examples of mixtures: metal alloy, air, saline solution, smoothie etc.

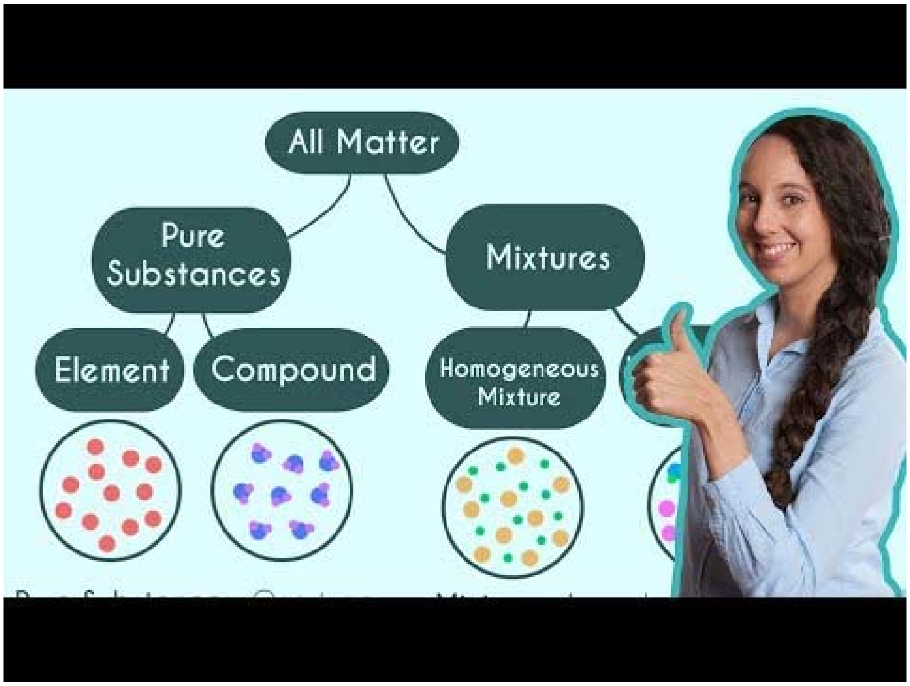
Mix of oil and water (heterogeneous)   Copper wire (element)

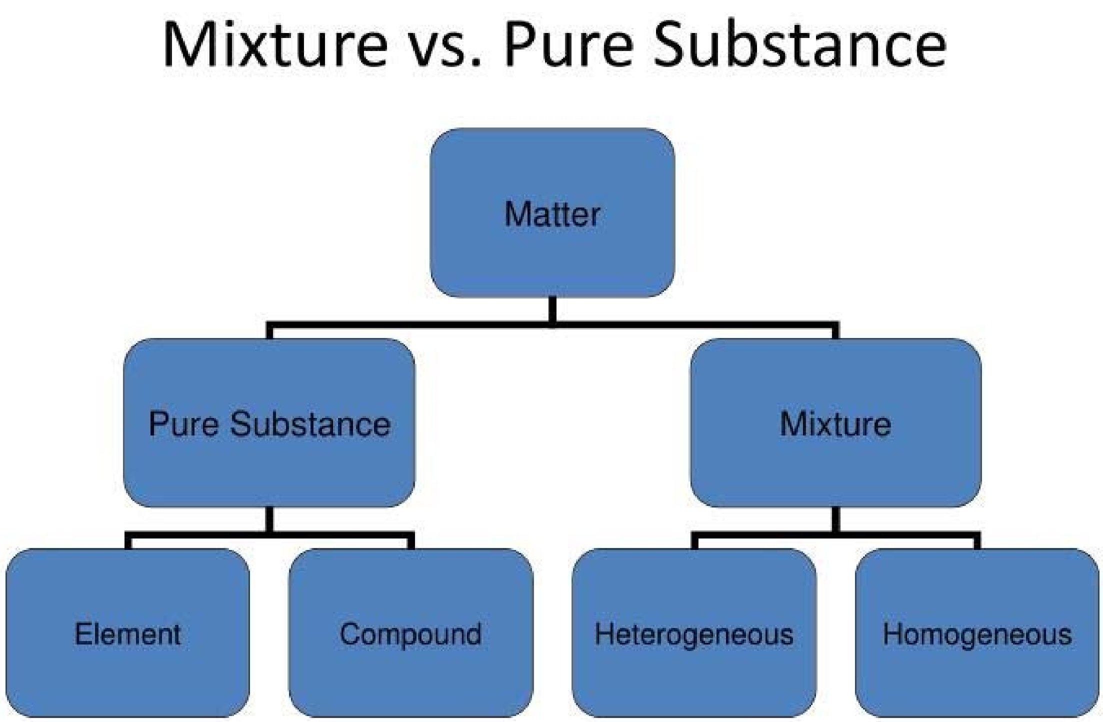
Two phases mixtures water, pure substance



Watch this out!

https://www.youtube.com/watch?v=pWZlICXw3Ng&t=98s





Questions:

1. Identify each of the following as an element, a compound or a mixture? Coke, mud, Ozone gas, table sugar, baking soda, copper wire

a. compound: two or more substances chemically combined

b. element: same type of substances either one or two
c. mixture

2. What is the basic difference between elements and compounds?
3. What is the similarity between elements and compounds?

Ans: 1. Coke: mixture, Mud: mixture, Ozone gas: element, Table sugar: compound, Baking Soda: compound, copper wire: element

2. Elements are composed of only one type of pure substances. Whereas, compounds are pure substances but they are made of two or more different types of pure substances combined together to produce a new substance with unique properties and characteristics.

3. Both elements and compounds are pure substances and their composition is uniform and they have their own characteristics and properties.

Chapter Objectives

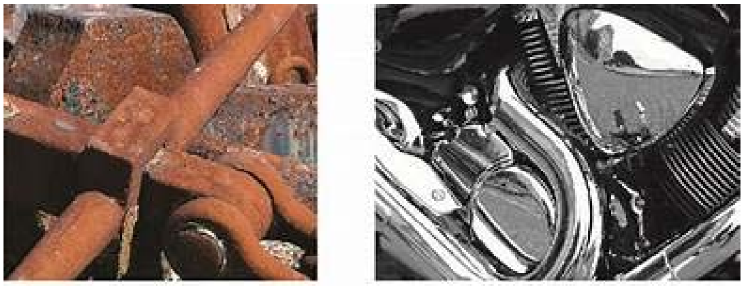
VI. Physical and Chemical Properties and Change

Physical Properties are those that can be observed or measured without changing the composition of the materials. Physical properties are determined by a substance's outside appearance. Chemical properties are those that determines how a substance can be converted to another substance. A substance reacting ability is defined by chemical properties.

A physical change alters a substance's shape, state without changing its original composition. A Chemical change or a chemical reaction converts one materials to another and therefore a totally new substance is formed with its own new properties and structures. In physical change original substances can be separated or recovered applying some physical methods like filtration, distillation etc. In chemical change, since new compounds are formed, only chemical method can be applied to obtain original substances.

Preparing smoothie or boiling water would be an example of physical change.
Whereas, rusting on iron, digestion of food in our body, electrolysis of water are examples of chemical change.


physical change

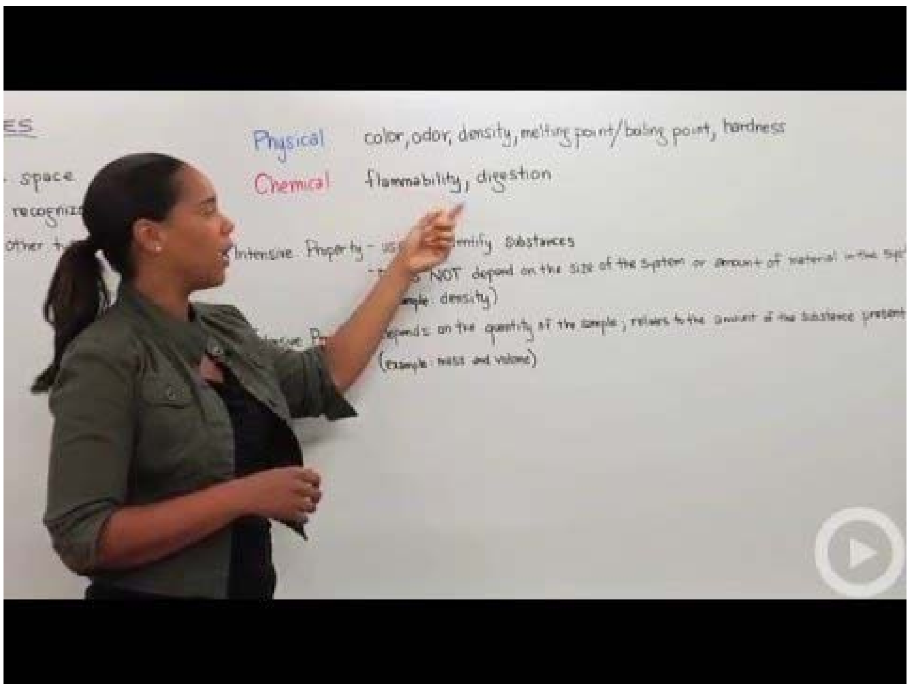


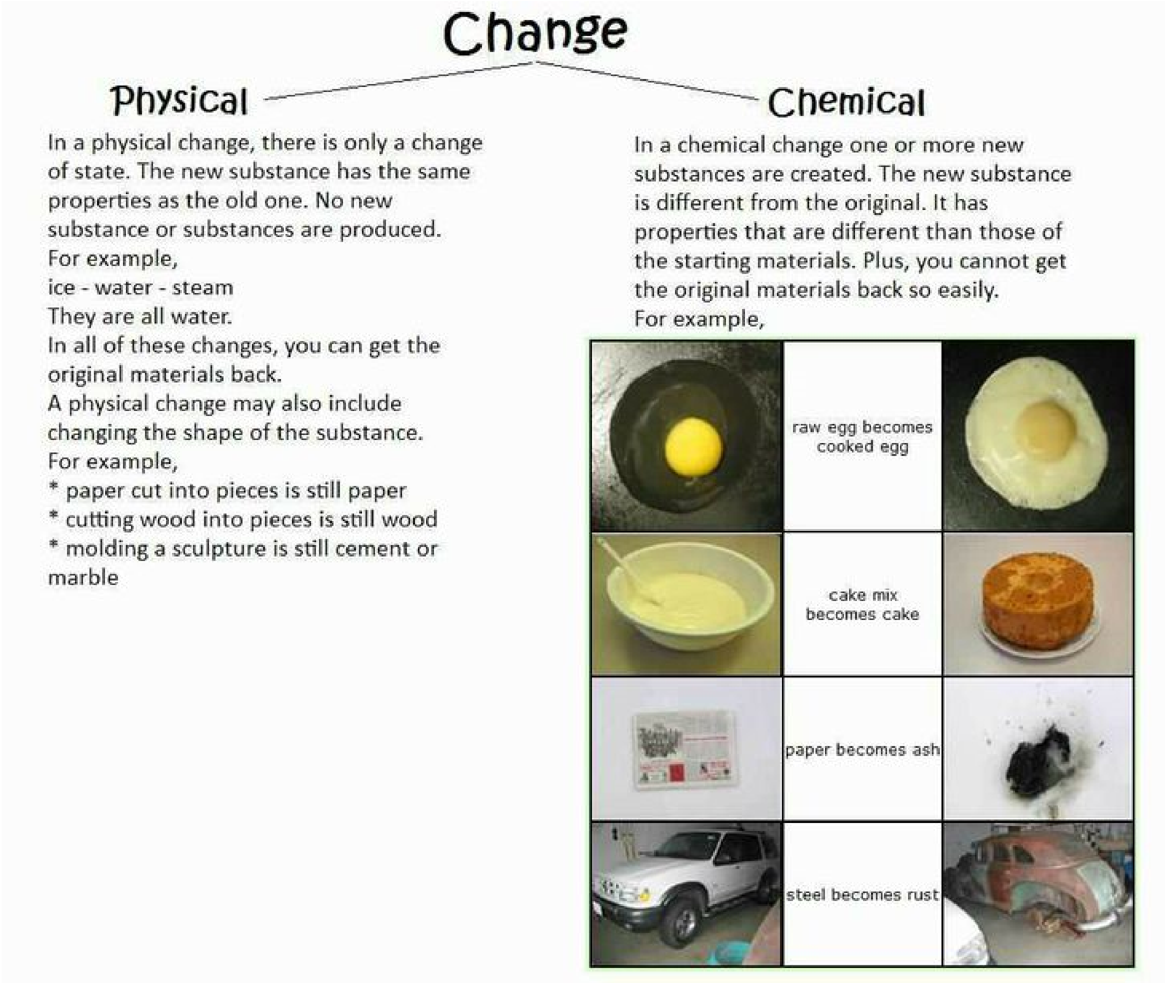
(a) (b)

Chemical change

Watch this out

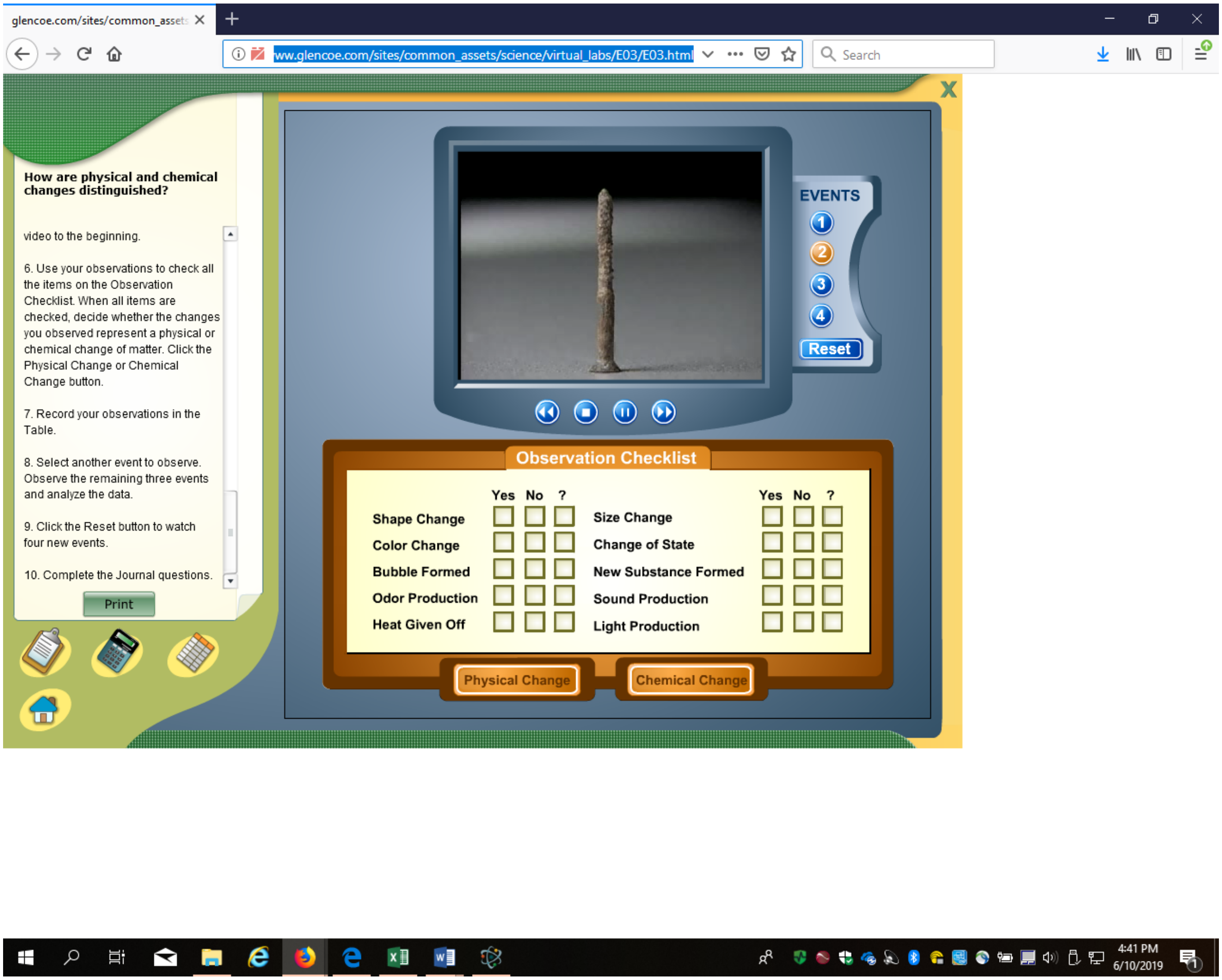
https://www.youtube.com/watch?v=UM_LrhxNxy4





Go to the following activity and complete the activity:

http://www.glencoe.com/sites/common_assets/science/virtual_labs/E03/E03.html



Questions:

1. When a chunk of dry ice (solid CO_2) is placed out in the air, the solid gradually disappears and a gas is formed above the solid. Does it indicate that a chemical or physical change has occurred?

2. Characterize each process as a physical change or a chemical change

   a) making ice cubes from water
   b) burning natural gas
   c) silver jewelry tarnishing
   d) a pile of snow melting
   e) fermenting grapes to produce wines

Ans: 1. Physical change

2.a) physical change

b) chemical change
c)chemical change
d) physical change
e) chemical change

Chapter Objectives

VII. Metric System and SI System of Measurements

Metric system is the oldest method of measurement. In each type of measurement, there is a base unit. The other units are related to the base unit by power of 10. These are called metric prefixes. The prefix of the unit name indicates if the unit is larger or smaller than the base unit.
Length is measured by determining the distance between two points. Mass is determined by the amount of matter in an object. Volume is determined by the amount of space occupied by a three -dimensional object.

Modern version of metric system is called International System of Units (SI).

Metric Base Units

The metric system uses the following base units:

Unit of Measurement	Name of Unit	Abbreviation
Length	Meter	m or cm
Mass	Gram	g
Volume	Liter	L

Find below common metric prefixes.

Metric Prefixes and Symbols		
MULTIPLICATION FACTOR	PREFIX	SYMBOL
1 000 000 000 000 000 000 = 10^{18}	exa	E
1 000 000 000 000 000 = 10^{15}	peta	P
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto	h
10 = 10^{1}	deka	da
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	m
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

Therefore 9 ml= 9/1000= 0.009 l(liter)
12 kg= 12*1000= 12000g

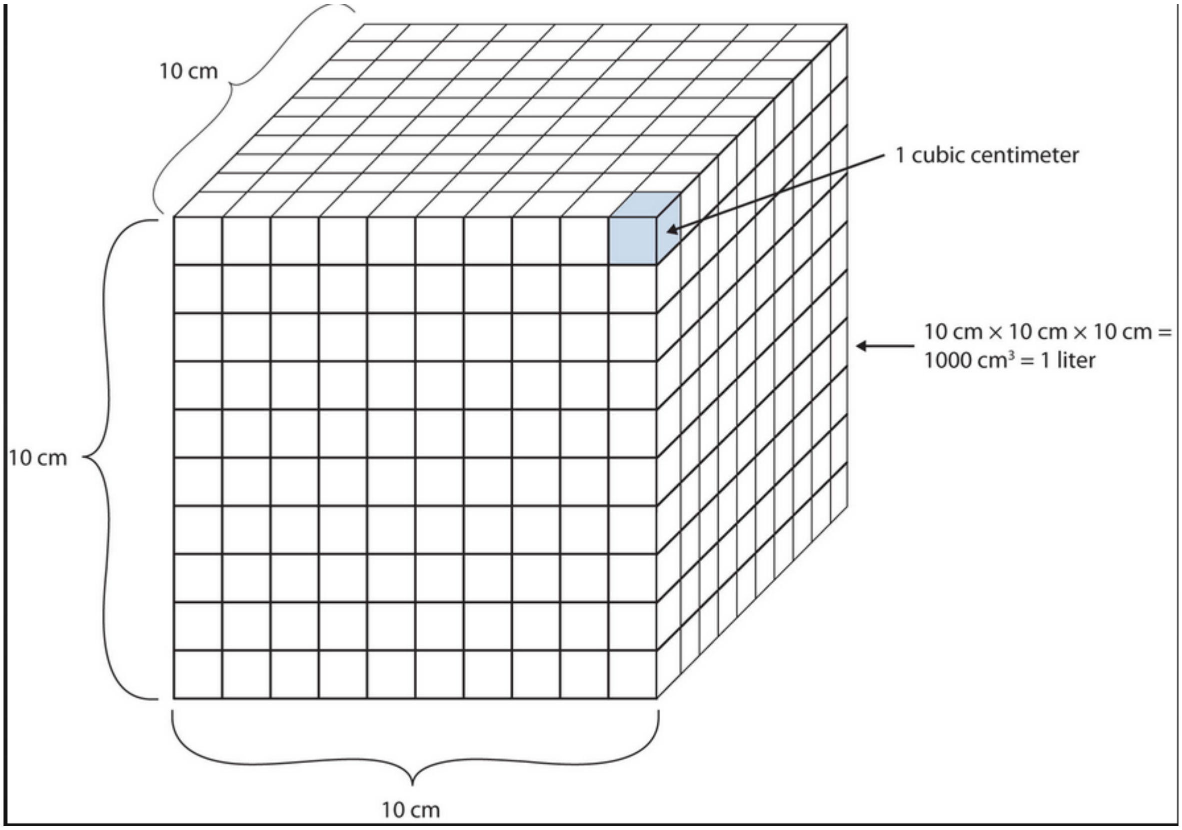
23 cm= 23/100= 0.23 m

Metric prefixes can be equally applied for SI units. Please find below common SI units.

***SI* Units**

Unit of Measurement	**Name of Unit**	**Abbreviation**
Length	Meter	m
Mass	Kilogram	kg
Temperature	Kelvin	K
Time	Second	s
Amount of Substance	Mole	mol
Electric Current	Ampere	I
Luminous Intensity	Lumen	I_v

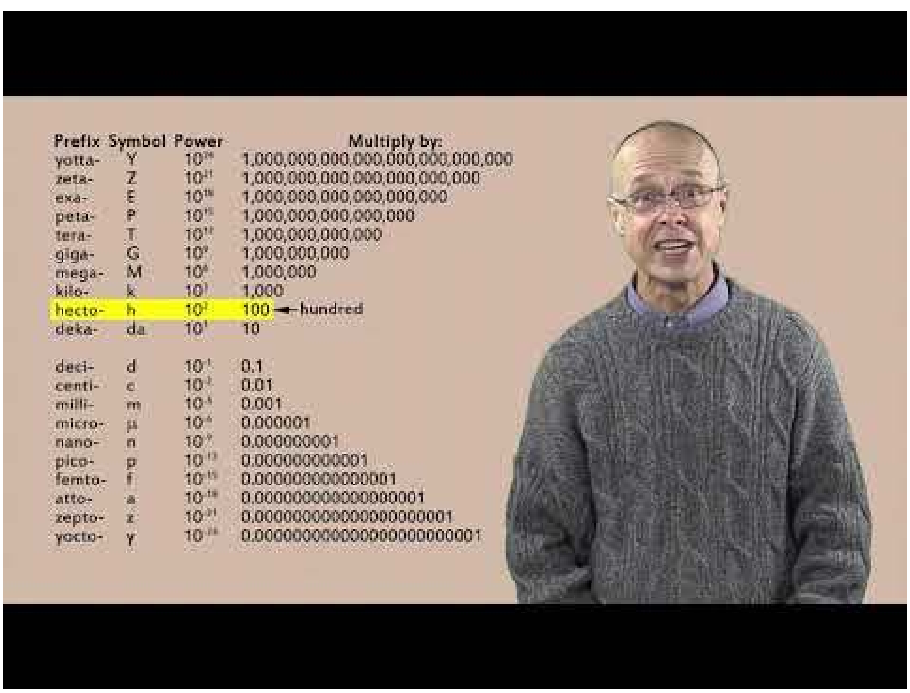
*****The new definition of the kilogram sets it equal to the mass of 1.4755214 x 10^{40} photons from a cesium atom.**
Kelvin is defined in terms of Boltzman constant
Mol is defined in terms of Avogadro number $6.02214076 \times 10^{23}$ mol^{-1}.



Liter: It is a nonstandard metric unit. Liter is defined as volume of 0.1 m cube or 1 decimeter cube. A smaller non SI unit is often used to measure volume which is 1 milliliter. Since 1000ml = 1L and 1 L contains 1000 cm3, therefore 1 cm3= 1ml. Usually 1 cm3 is used for solid substances and 1 ml is used liquid substances.

Watch this video and have fun!!!

https://www.youtube.com/watch?v=xTgRCJQ6w48



Questions:

1. What is the unit of length in metric system?

2. 1 cc is the unit of what quantity?

Ans: 1. Meter
2.volume

Chapter Objectives

VIII. Scientific Notation

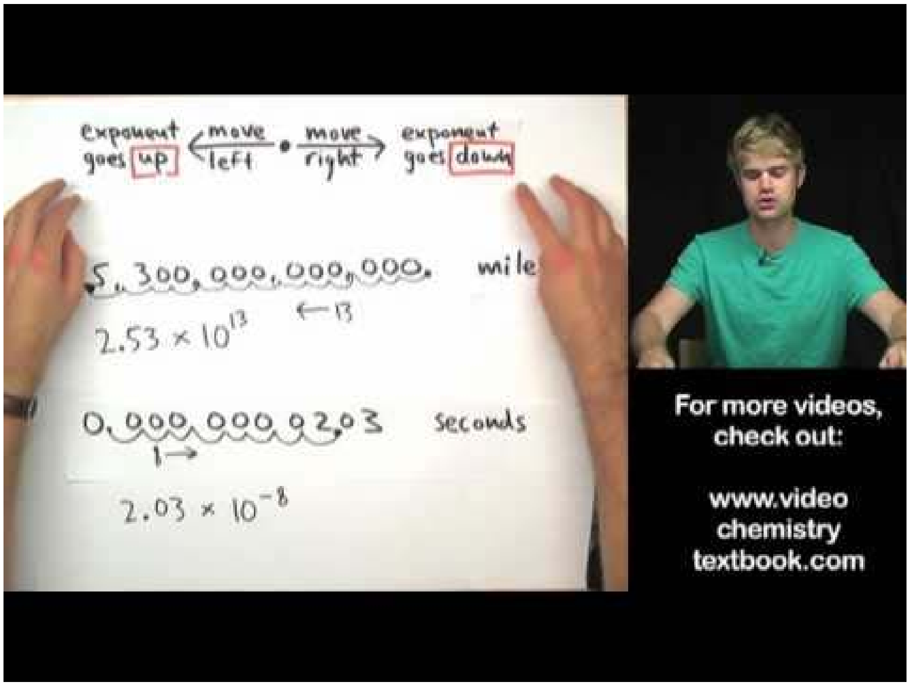
In scientific notation, a number is written as $x*10^y$ .The number x is called coefficient is a number between 1 and 10. The value y is called exponent, which can be any positive or negative whole number. The decimal and scientific notation forms of a number always contain same number of significant figures. The decimal point is placed after the first nonzero digit and every other digits are written after the decimal point. Usaully a very large or a very small number is written in scientific notation.

To multiply exponential term: add the exponents.
To divide exponential terms: subtract the exponents.

Example: 600000 can be written as $6.*10^5$
0.00000328 can be written as $3.28*10^{-5}$

Watch this out!

https://www.youtube.com/watch?v=Dme-G4rc6NI&t=136s



Questions:

1. Write each number in scientific notation:
   a) 95200
   b) 6780,000
   c) 0.000725

2. Write the following using standard notation:
a) $1.60 * 10^{-9}$
b) $5.2131*10^{2}$
c) $7.*10^{-5}$

Ans: 1. a) $9.52*10^{3}$
b) $6.78 *10^{7}$
c) $7.25*10^{-4}$

2.a) 0.0000000016
b) 521.31
c) 0.00007

Chapter Objectives

IX. Exact number and Measured number

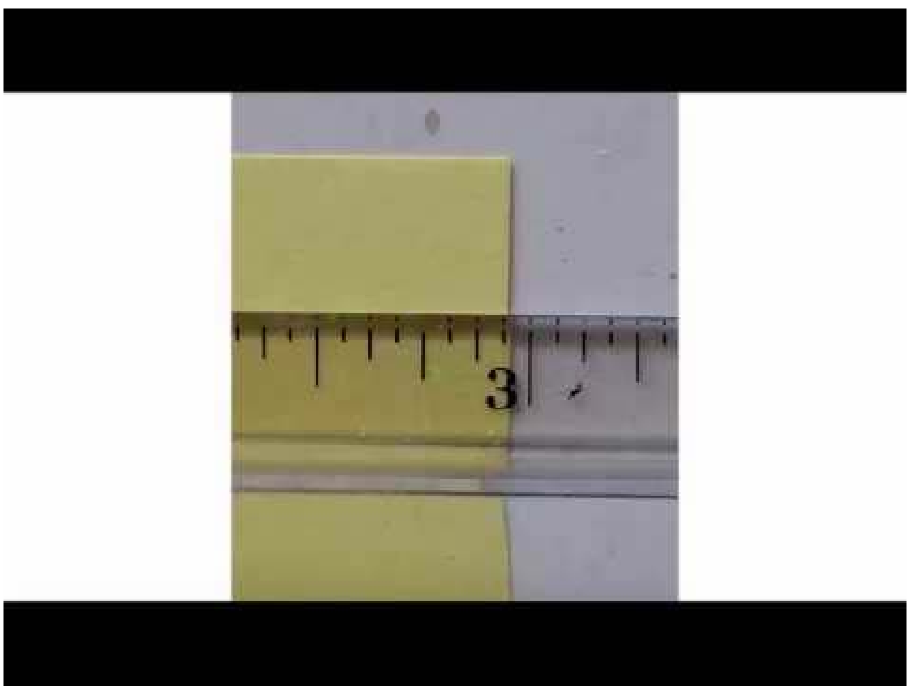
An exact number results from counting objects or is a part of a definition. For example, 30 students present in class. 30 is the exact number. There are 60 minutes in 1 hour. 60 is the exact number. A measured number results from a measurement or observation and contains some uncertainty also called Inexact number. Limitation of the measuring device and limited powers of the observation of the individual making the measurement involving a degree of uncertainty or error. That is why measured number are sometimes called approximate number.

Example of exact number: 30 students in class, 12 oranges. Example of measured number: the child weights 30.5 lbs, The height of Mount Everest is 8,848 meters.

Any exact doesn’t have any uncertainty in it. In case of measured number always, the last digit is uncertain. The uncertain number depends on the calibration of the device.

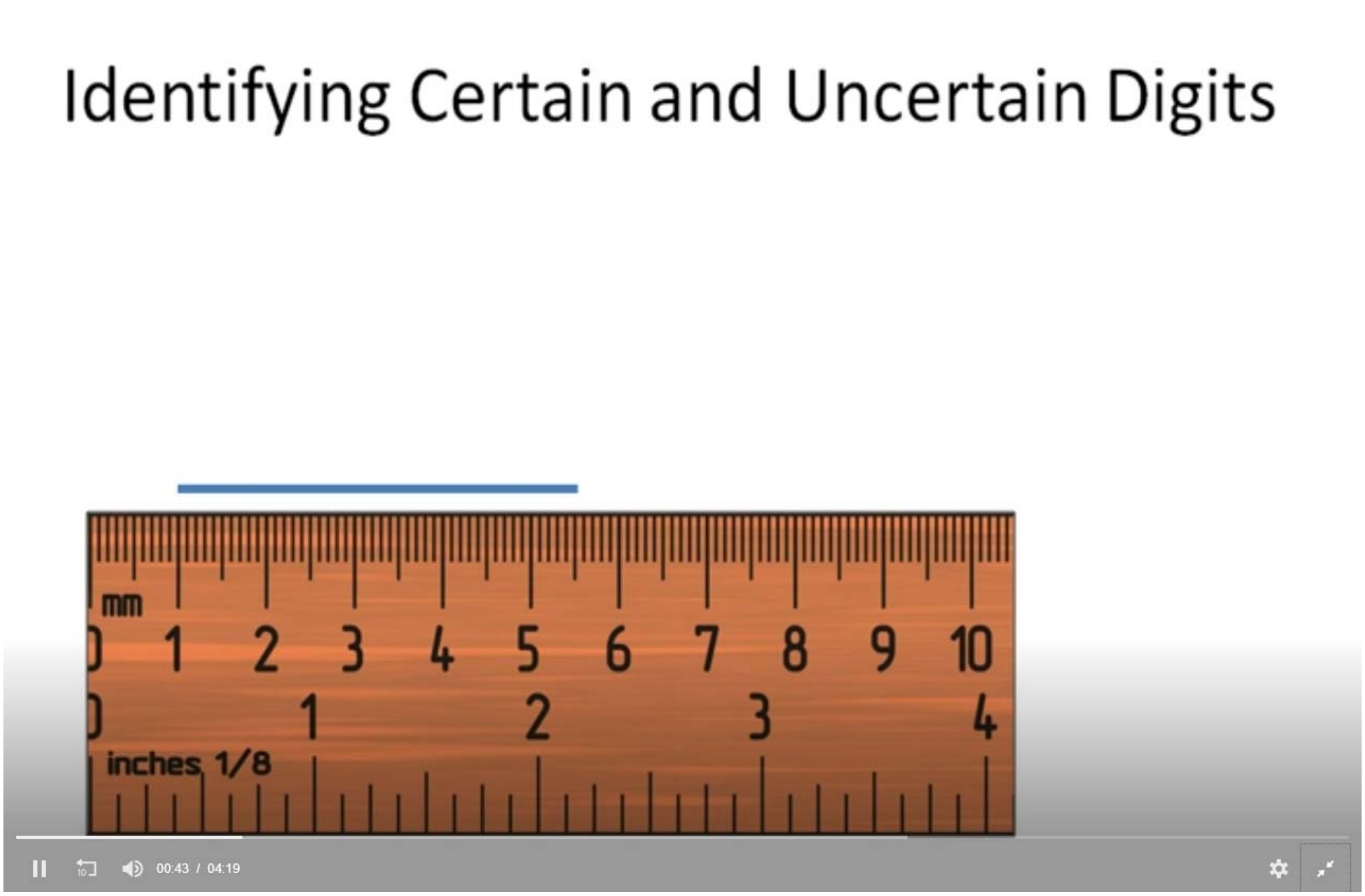
In a measured number always, all digits are certain except the last one. The last digit in a measured number of based on instrumental precision and human eye estimation. It is called uncertain digit or estimated digit. Certain and uncertain digits together make significant figures.
Watch the following video about certain and uncertain digits.

https://www.youtube.com/watch?v=TKoskMGAmSo



Following tutorial may help you to understand the concept.

https://www.sophia.org/tutorials/identifying-certain-and-uncertain-digits



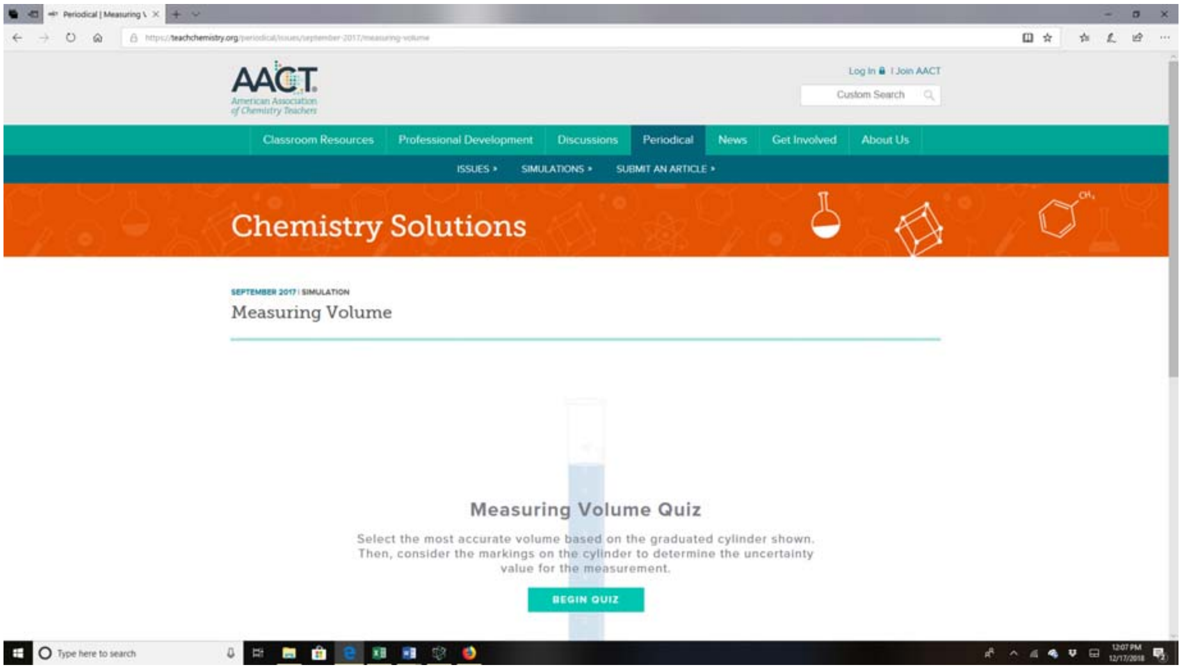
Questions:

1. Indicate whether the following numbers are exact or inexact?

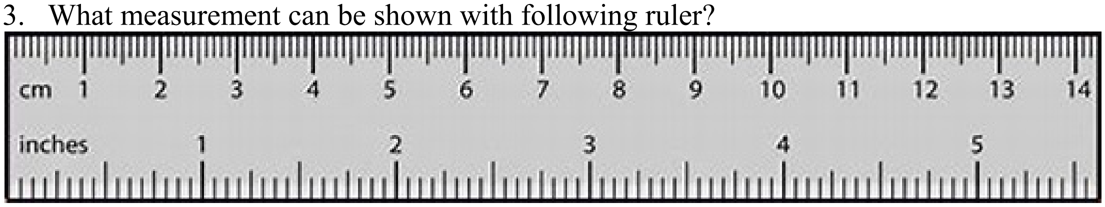
    a) The length of a river
    b) Conference attendees

2. Go to the following link Take the quiz:

https://teachchemistry.org/periodical/issues/september-2017/measuring-volume



3. What measurement can be shown with following ruler?



Ans:

1. a) measured
   b)exact

2. **Quiz**
3. **14.30 cm**

[Chapter Objectives]

X. Significant Figures

Significant figures are digits in a measurement that are known with certainty plus one digit of uncertainty.
Number of sig. fig= all certain + one uncertain digit

Determining Rule:
1. In any measurement, all nonzero digits are significant.
2. Zeros in between two nonzero digits are significant

3. Leading zeros (zeros to the left of the first nonzero digit) are never significant.
4. Training zeros (zeros to the right of last nonzero digit) only significant if there is a decimal point.

Example: 3.2072 has 5 sig. fig.
0.0000007 has only 1 sig. fig.
630 has 2 sig fig but 630.0000 has 7 sig fig. All the zeros are significant in the second case.

Questions:

4. For each of the following measurements, give the number of significant figures present and the uncertainty associated with the measurement.

   a. 727.23
   b. 0.1051
   c. 29.230
   d. 647,000,000

Ans:a. 5, b. 4, c. 5, d. 3

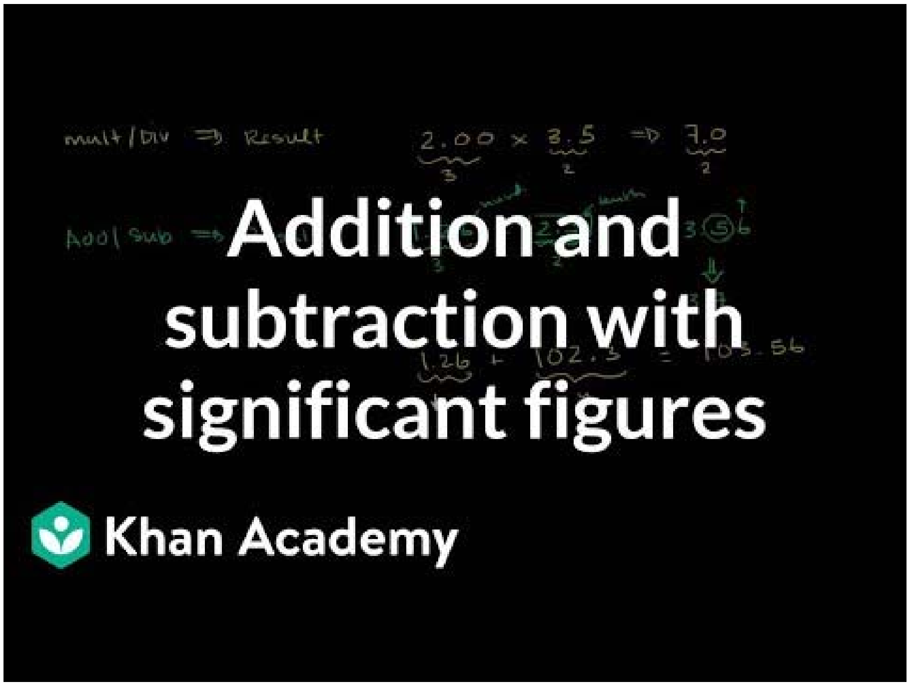
Chapter Objectives

XI. Significant figures used in calculations

Operational Rules:

1. In multiplication and division, the number of significant figures in the final answer is the same as the lowest number of significant figures in the measurement.

2. In addition, or subtraction, the number of significant figures in the final answer has the same number of decimal places as the digit with lowest decimal places used in the measurement.



https://www.youtube.com/watch?v=iorZdz4dsBU&t=2s

Example:

A) Determine: 25.3+ 12.84+ 486

486
25.3
12.84
524.14

Final ans: 524(lowest zero decimal place used in calc)

B) Determine: 15.6 × 13.523 * 0.0081

The original answer is 1.70876628
Lowest sig fig used in calc. is 2 (0.0081). **Therefore, the final answer is 1.7**

Sometimes exponents are used in calculations. Note that, powers are added while number are multiplied, and subtracted when numbers are divided.

For example:($(1.35 \times 10^{7}) \times (6.2 \times 10^{-3})= 8.37 \times 10^{4}$

Final answer: 8.4×10^{4}

Questions:

1. Perform the following computation and express your answer with proper significant figures.

   a. 6.7321×0.0021
   b. 16.340/0.0031
   c. 8.3+ 1.2 + 1.8
   d. $4.73 \times (17.6\text{-}13.73)$

Ans: a) 0.014
b)5300
c) 11.3
d) 10.

Chapter Objectives

XII. Rounding off, Accuracy and Precision

Rounding off: To write the final answer with proper sig. fig. we must round off the original answer. It can be done in two ways:
If the first number that must be dropped is 4 or less, drop it and all remaining numbers
If the dropped number that must be dropped is 5 or greater, round the number up by adding 1 to the last digit that will be retained. Example: a number 66.453 can be written in many different significant figures:

1) 4 significant figure: 66.45
2) 3 significant figures: 66.5
3) 2 significant figures: 66
4) 1 significant figure: 70 (reduces significant figure but value of the number is not changed)

Raising to a power using powers of ten:

1. Raise the number to the correct power.
2. Multiply the exponents.

Example $(2.0 \text{ x } 10^3)^4 = 16 \text{ x } 10^{12} = 1.6 \text{ x } 10^{13}$

(Use correct scientific notation; use correct number of significant figures)

Finding roots using powers of ten:

1. If the exponent is not evenly divisible by the root, rewrite the number with a new power of ten that is evenly divisible.
2. Find the root of the number,

Divide the exponent by the root to be taken.

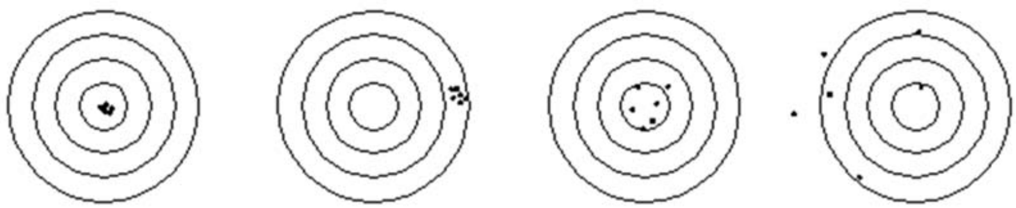
Example: $\sqrt[3]{8.1x10^3} = \sqrt[3]{81x10^2} = 9.x10^1$

Accuracy: It means how close a number is compared to the true value. Mathematically accuracy is determined. when a measured number is evaluated with respect to the significant figures of a number considered to be true value.

For example: The true value of the length of a pen is 15.63 cm. 15.6 cm is less accurate than 15.63 cm.

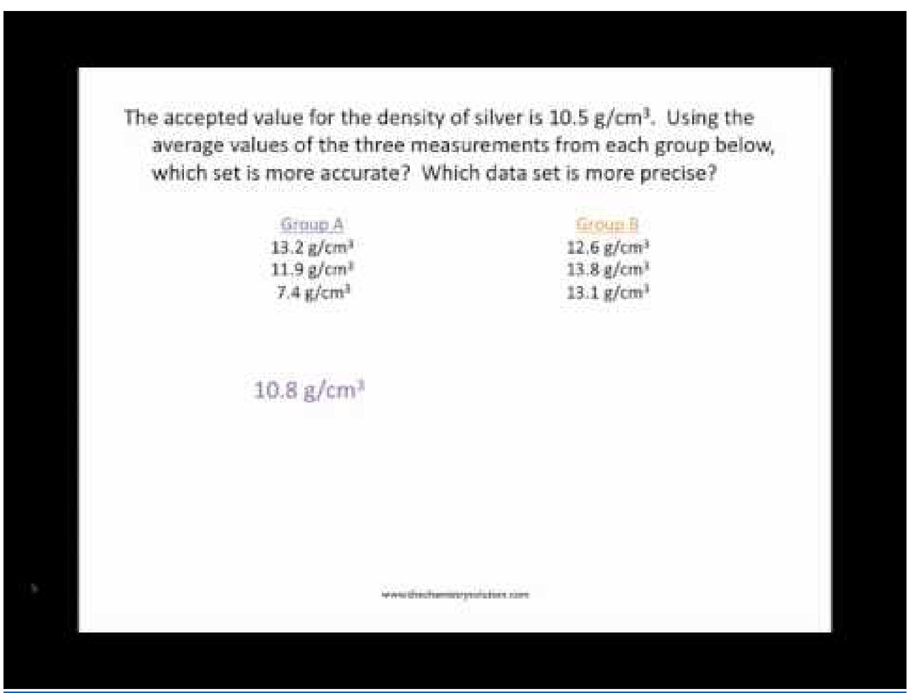
Precision: It means how reproducible the measured number is compared to the true value. It also means how consequent measurements of an object are close to each other Mathematically, it is determined when the measured number is compared to the number of decimal places in the significant digits.

For example, measurement of 25.612 is more precise than 25. Precision always depends on instrument.



accurate and precise   precise but not accurate   accurate but not precise   not accurate or precise

Watch the following video for Accuracy and Precision:



https://www.youtube.com/watch?v=TzLnO04uO30

Questions:

1. Round off the following number to 3 significant figures
   a. 6715
   b. 102.415

2. A student conducted an experiment four times and gets a solution concentration of 4.9M, 5.1M, 5.8M, and 5.2M. The true concentration of the solution is 5.0M. What do you think about he precision and accuracy of the measurement?

Ans: 1. a) 6720
b)102

2.Imprecise and inaccurate.

Chapter Objectives

XIII. Conversion Factors

A conversion factor is a ratio that specifies how one unit of measurement is related to another unit of measurement. Chemists often need to convert the value from one unit to another unit. When the equalities are written as a ratio, it becomes a conversion factor.
To convert the measured number from one unit to another unit we always take the following path

1) First we define the given quantity with number and unit and needed unit.
2) Then we set up the conversion factor as a ratio to convert from one unit to another unit. This conversion factors are measured or exact number depending upon the quantity. Always the desire unit is on the top and the unit to be cancelled is written as denominator in the ratio.
3) We multiply the the given quantity by the appropriate conversion factor and find the new value with the target unit.

1 min= 60 sec ……………………………………………this an equality

$\frac{1\ \text{min}}{60\ \text{sec}}$ or $\frac{60\ \text{sec}}{1\ \text{min}}$ these two quantities are same. ………………….this is conversion factor

There are two sets of conversion factor for every relationship.
Conversion factor can be used within a system of units or between different units of system.

Case1: Conversion factor can be used within a system of units or between different units of system. (defined relationship)

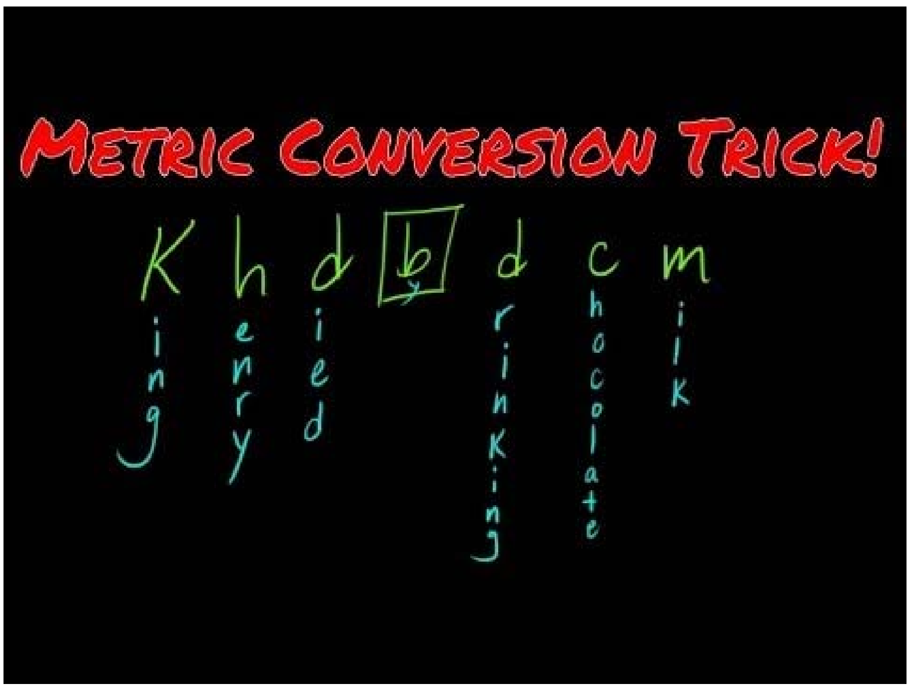
Example problem: A lab test showed an individual's cholesterol level to be 186 mg/dL. Convert this quantity into g/dL

given 1g= 1000mg

$$\frac{186mg}{1dL} \times \frac{1\,g}{1000mg} = 0.186\,g/dL$$

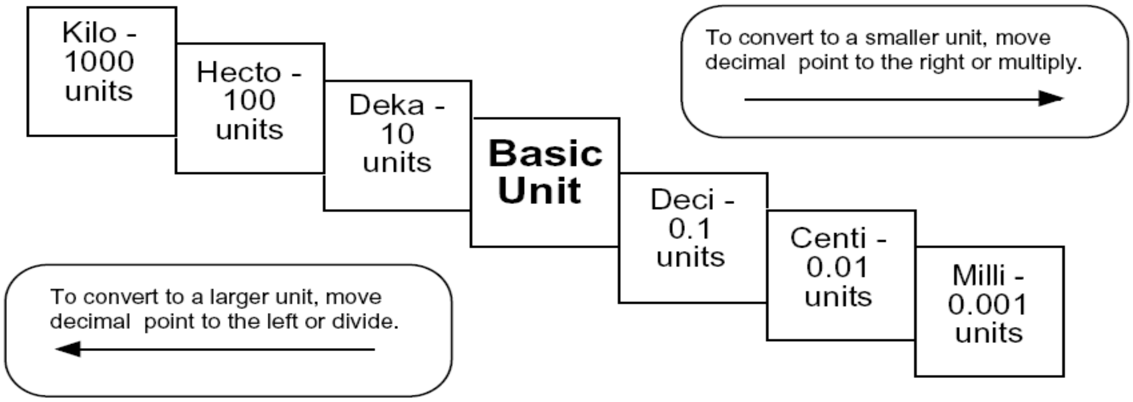
In order to obtain metric to metric conversion factor, the meaning of metric prefixes and their values must be known.

For more information watch:



https://www.youtube.com/watch?v=5tHpDzXP-lg

Metric conversion: ladder method



How do you use ladder method?

1st – Determine your starting point.

2nd – Count the "jumps" to your ending point.

3rd – Move the decimal the same number of jumps in the same direction.

Example: 4km =__________m

↑start ↑End

4. 0 0 0 = 4000m

Write the abbreviation of following Metric Conversions:

1) Kilogram _____
2) Meter _____
3) Gram _____
4) Milliliter _____
5) Millimeter _____
6) Liter _____
7) Kilometer _____
8) Centimeter _____
9) Milligram _____

Try these conversions, using the ladder method.

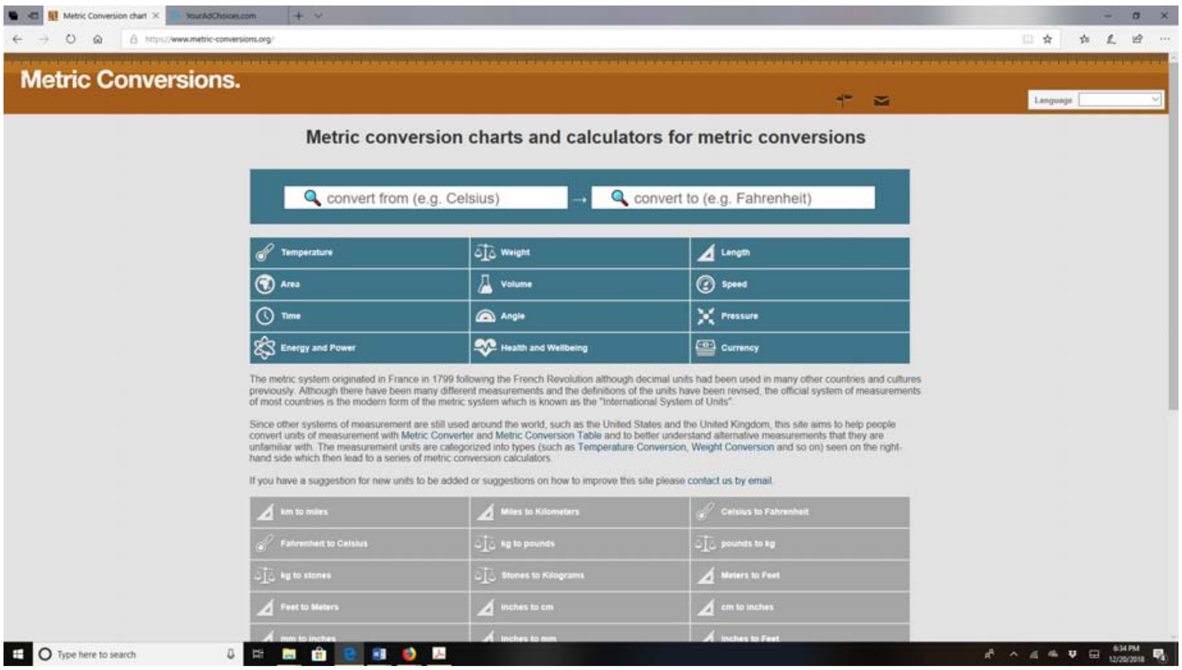
10) 2000 mg = _______ g
11) 104 km = _______ m
12) 480 cm = _____ m
13) 5.6 kg = _____ g
14) 8 mm = _____ cm
15) 5 L = _______ mL
16) 198 g = _______ kg
17) 75 mL = _____ L
18) 50 cm = _____ m
19) 5.6 m = _____ cm
20) 16 cm = _______ mm
21) 2500 m = _______ km
22) 65 g = _____ mg
23) 6.3 cm = _____ mm
24) 120 mg = _____ g

Compare using <, >, or =.

56 cm 6 m

7 g   698 mg
5 g   508 mg
1,500 mL   1.5 L
536 cm   53.6 dm
43 mg   5 g
3.6 m   36 cm

<u>For more information visit:</u>



https://www.metric-conversions.org/

Questions:

1. Convert each of the following measurements into meters?
a. 2.5×10^3 mm
b. 25 μm

Ans: a. 2.5 m, b. 25E-6 m

Case 2: Metric to English conversion factors are specified with different number of significant figures. (measured relationship). They are called equalities. For example: 1 mile= 1.61 km. mile is the English unit and kilometer (km) in the metric unit.

Example #1 : Capillaries, the microscopic vessels that carry the blood from small arteries to small veins, are on the average only 0.1cm long. What is the average length of a capillary in inches?

Given 1 inch= 2.54 cm

$$0.1 \text{ cm} \times \frac{1 \text{ inch}}{2.54 \text{ cm}} = 0.0393 \text{ in} = 0.04 \text{ in}$$ (lowest 1 sig fig used in calc)

Here is the table of most common metric to metric and metric to English conversion factors:

Example #2: Convert 10.8 ft to meters

Given that 12 in = 1ft, 2.54 cm= 1 inch and 100 cm = 1meter

$$\text{Pathway: } \cancel{\text{ft}} * \frac{12 \cancel{\text{in}} * 2.54 \cancel{\text{cm}} * 1 \text{ m}}{1 \cancel{\text{ft}} \quad 1 \cancel{\text{in}} \quad 100 \cancel{\text{cm}}} = \text{meter}$$

Now plug in the numbers in tis problem:

$$\frac{10.8 \text{ ft} * 12 \text{ in} * 2.54 \text{ cm} * 1\text{m}}{1\text{ft} * \quad 1 \text{ in} * \quad 100\text{cm}} = 3.28 \text{ m (ans)}$$

Example#3: Convert 58.8 lbs to kg.

Given : 58.8 lbs, needed kg. conversion factor: 2.205 lbs= 1 kg

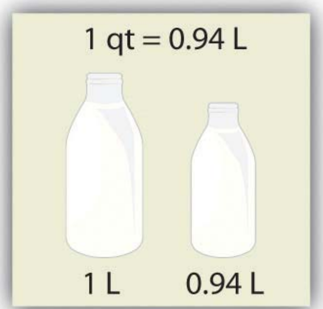
$$\text{pathway: lbs} * \frac{1\text{kg}}{2.205 \text{ lbs}}$$

now use the values given in the problem,

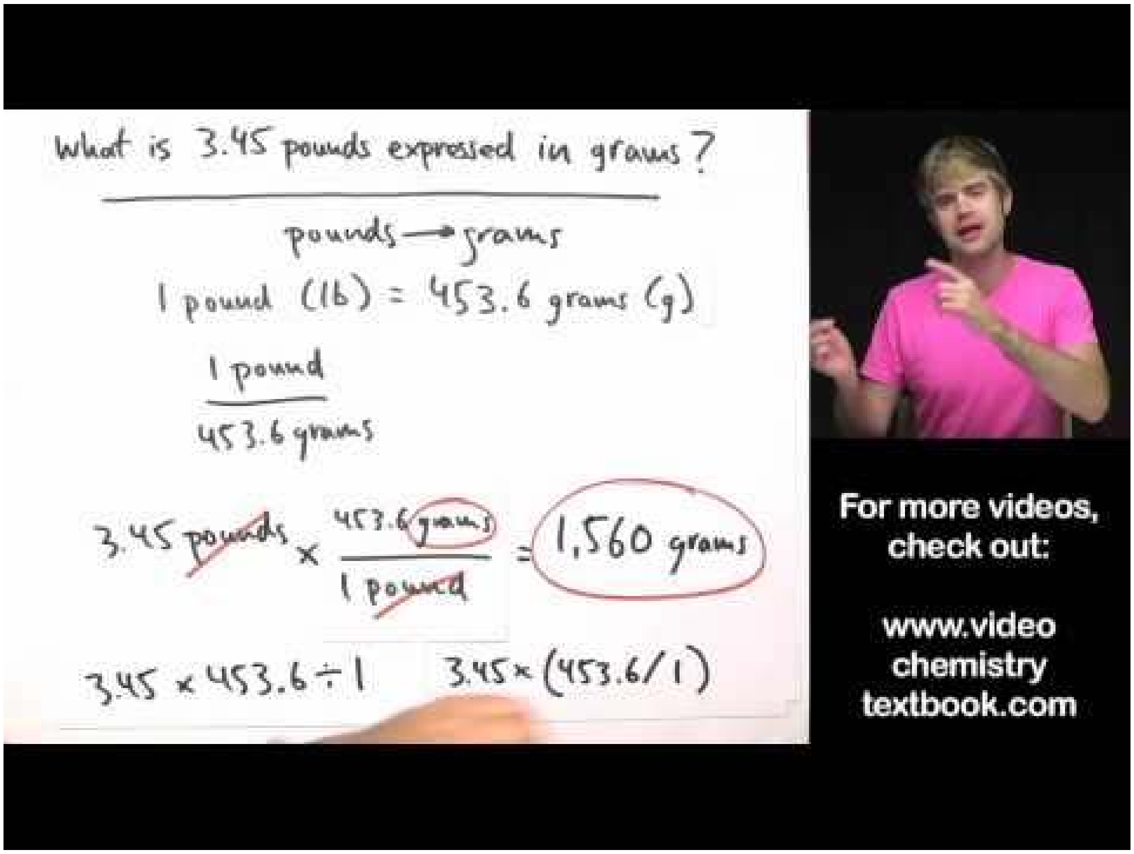
$$\frac{58.8 \cancel{\text{lbs}} * 1 \text{ kg}}{2.205 \cancel{\text{lb}}} = 26.7 \text{ kg}$$

Below is the table with common English to metric equalities.

Distance		
1 inch	= 2.54 centimeters	= 25.4 millimeters
1 foot	= 0.305 meter	= 30.48 centimeters
1 yard	= 0.9144 meter	
1 mile	= 1.61 kilometers	= 5,280 feet
1 kilometer	= 1,000 meters	= 0.6214 mile
1 meter	= 100 centimeters	= 1,000 millimeters
1 meter	= 3.28 feet	
1 centimeter	= 0.3937 inch	= 10 millimeters
1 millimeter	= 0.039 inch	= 0.1 centimeter
1 micron	= 10^{-4} centimeter	= 10^{-6} meter
10^{-6} meter	= 1micrometer	
Volume		
1 kiloliter	= 1,000 liters	= 1 cubic meter
1 liter	= 1,000 milliliters	= 1,000 cc
1 milliliter	= 1 cc (exactly 1.000027 cc)	
1 fluid ounce	= 29.57 milliliters	
1 US gallon	= 3.785 liters	
1 Imperial gallon	= 4.546 liters	
Weight		
1 kilogram	= 1,000 grams	= 2.2 pounds
1 gram	= 1,000 milligrams	= 0.035 ounce
1 milligram	= 1,000 micrograms	= 1/1,000 gram
1 microgram	= 10^{-6} grams	= 1/1,000 milligram
1 nanogram	= 10^{-9} grams	= 1/1,000 microgram
1 pound	= 0.45 kilogram	= 16 ounces
1 ounce	= 28.35 grams	

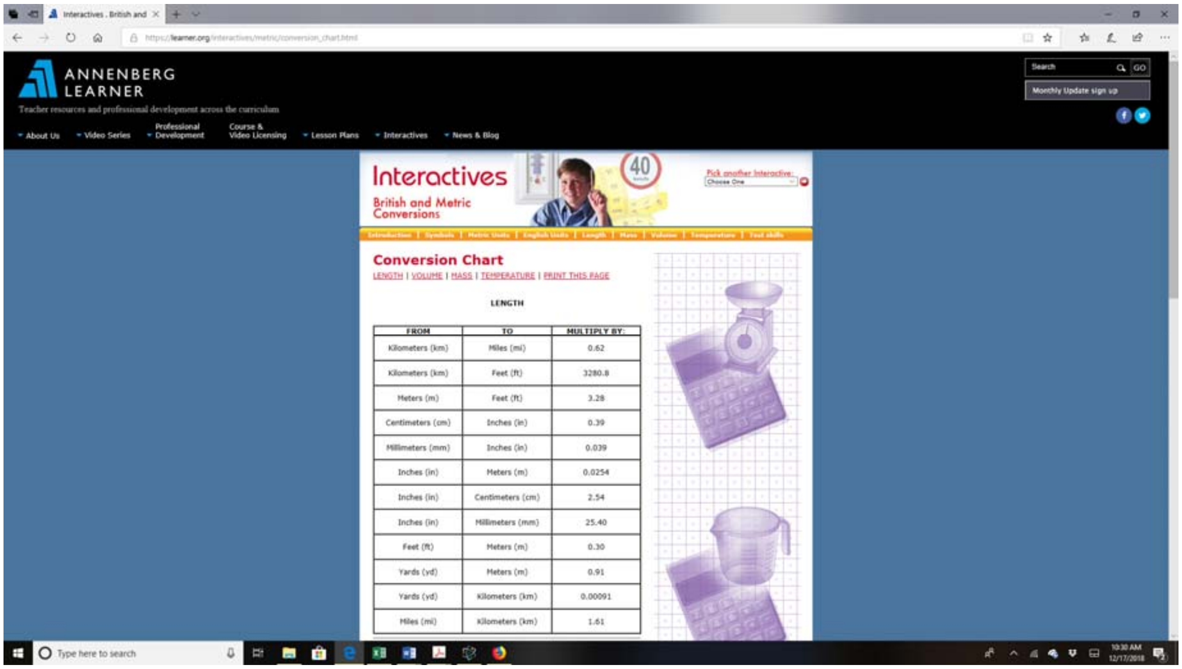


For more information watch:



https://www.youtube.com/watch?v=7N0lRJLwpPI

For more information visit:


ANNENBERG LEARNER

Teacher resources and professional development across the curriculum

Interactives

British and Metric Conversions

Conversion Chart

LENGTH | VOLUME | MASS | TEMPERATURE | PRINT THIS PAGE

LENGTH

FROM	TO	MULTIPLY BY:
Kilometers (km)	Miles (mi)	0.62
Kilometers (km)	Feet (ft)	3280.8
Meters (m)	Feet (ft)	3.28
Centimeters (cm)	Inches (in)	0.39
Millimeters (mm)	Inches (in)	0.039
Inches (in)	Meters (m)	0.0254
Inches (in)	Centimeters (cm)	2.54
Inches (in)	Millimeters (mm)	25.40
Feet (ft)	Meters (m)	0.30
Yards (yd)	Meters (m)	0.91
Yards (yd)	Kilometers (km)	0.00091
Miles (mi)	Kilometers (km)	1.61

https://learner.org/interactives/metric/conversion_chart.html

Questions:

1. A chemistry student weighs 83.1 kg and 1.93 m tall. What are the person's equivalent measurements in pounds and feet?
2. What volume of water in gallons would be required to fill a 30.ml of container?

Ans: 1. weight=183 lbs, height=6.33 ft
2. 0.0079 gal

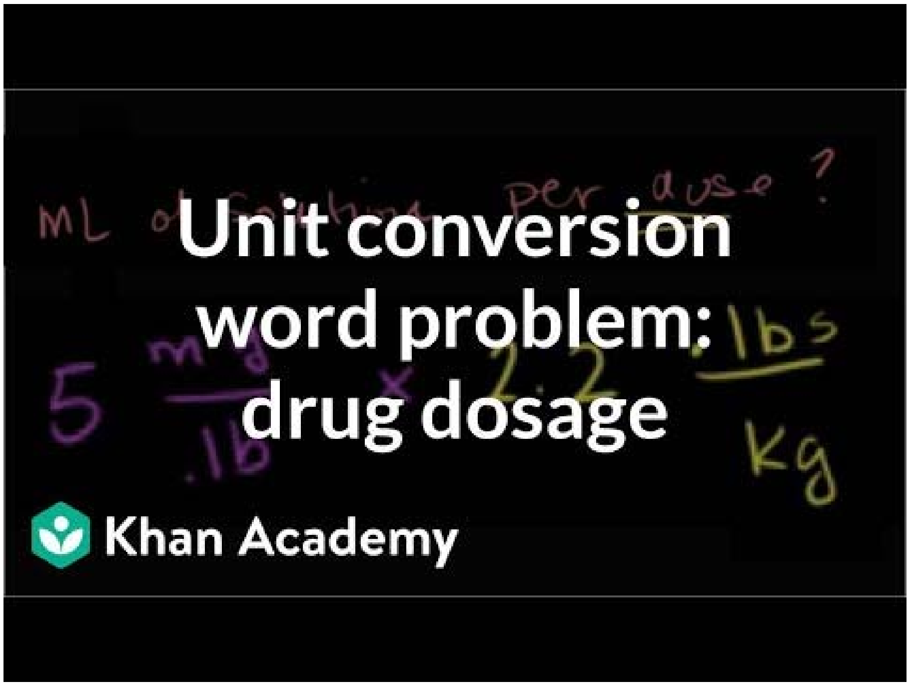
Chapter Objectives

XIV. Solving Problems with single or multi-step Conversion Factors

This process is called dimensional analysis. A general problem solving method in which the different units are associated with numbers and final result is calculate by converting one unit to another unit. calc. is set up from unit cancellation to target unit.

Step#1: Identify the units of known or given quantity and the units of target quantity
Step#2: Figure out the conversion factors required from given unit to target unit.
Step#3: Multiply the given quantity by one or more conversion factors in such a manner that the original units are canceled leaving only the desired unit.

Watch this out to solve drug dosage related problems that require conversion factors.



Example Problem:

(A) A dose of 250 mg of acetaminophen is prescribed for a 20-kg child. How many ml of Children's Tynenol (100. mg of acetaminophen per 2.5 ml) are needed?

Step#1: Identify given and target quantity and numbers:

Given: 250mg   target: ml

Step#2: Write the conversion factors:

Provided in the problem: $\frac{2.5\text{ ml}}{100\text{ mg}}$

Step#3. Multiply the given quantity by the conversion factor.

$$250\text{ mg} \times \frac{2.5\text{ ml}}{100\text{ mg}} = 6.3\text{ml (lowest 2 sig fig)}$$

Check: the answer is reasonable. Since the required dose is larger than standard dose, volume would be larger than standard.

Nurses Conversion units for drugs

<u>Drug Calculations</u>

Drug calculations vary depending on whether you are dealing with liquid or solid medications, or if the dose is to be given over a period of time. In this section I will go over each of these situations in turn.

It is very important that you know how drug dosages are worked out, because it is good practise to <u>always</u> check calculations before giving medication, no matter who worked out the original amount. It is far better to point out a mistake on paper than overdose a patient.

a) Tablets

Working out dosage from tablets is simple.

Formula for dosage:

$$\frac{\textbf{Total dosage required}}{\textbf{Dosage per tablet}} = \textbf{Number of tablets required}$$

Note-If your answer involves small fractions of tablets, it would be more sensible to try to find tablets of a different strength rather than try to make $\frac{1}{3}$ of a tablet for example.

Examples

1. A patient needs 500mg of X per day. X comes in 125mg tablets. How many tablets per day does he need to take?

Total dosage required is 500mg,
Dosage per tablet is 125mg

So our calculation is $\frac{500}{125}$

= 4 He needs 4 tablets a day

b) Liquid Medicines

Liquid medicines are a little trickier to deal with as they will contain a certain dose within a certain amount of liquid, such as 250mg in 50ml, for example.

To work out the dosage, we use the formula:

$$\frac{\text{What you want}}{\text{What you've got}} \times \text{What it's in}$$

Note: In order to use this formula, the units of measurement must be the same for 'What you want' and 'What you've got'; i.e. both mg or both mcg etc.

Examples

2. We need a dose of 500mg of Y. Y is available in a solution of 250mg per 50ml.

In this case,

What we want = 500 What we've got = 250 What it's in = 50

So our calculation is $\frac{500}{250} \times 50 = 100$

We need 100ml of solution.

3. We need a dose of 250mg of Z. Z is available in a solution of 400mg per 200ml. In this

case,

What we want = 250 What we've got = 400 What it's in = 200

So our calculation is $\frac{250}{400} \times 200 = 125$

We need 125ml of solution.

c) Medicine over Time

1) Tablets/liquids

This differs from the normal calculations in that we have to split our answer for the total dosage into 2 or more smaller doses.

Look at Example 1 again. If the patient needed the 500mg dose to last the day, and tablets were taken four times a day, then our total of 4 tablets would have to be split over 4 doses.

$\frac{\text{Total amount of liquid/tablets for day}}{\text{Number of doses per day}}$ = Amount to be given per dose

We would perform the calculation: $4 \div 4 = 1$ So he would need 1 tablet 4 times a day.

2) Drugs delivered via infusion

For calculations involving infusion, we need the following information:

- The total dosage required
- The period of time over which medication is to be given
- How much medication there is in the solution

Example

4. A patient is receiving 500mg of medicine X over a 20 hour period. X is delivered in a solution of 10mg per 50ml.

What rate should the infusion be set to? Here

our total dosage required is 500mg

Period of time is 20 hours
There are 10mg of X per 50ml of solution

Firstly we need to know the total volume of solution that the patient is to receive. Using the formula for liquid dosage we have:

$\frac{500}{10} \times 50 = 2500$ So the patient needs to receive 2500mls.

We now divide the amount to be given by the time to be taken: $\frac{2500}{20} = 125$

The patient needs 2500mls to be given at a rate of 125mls per hour

> **Note**: Working out medicines over time can appear daunting, but all you do is work out how much medicine is needed in total, and then divide it by the amount of hours/doses needed

d) Drugs labelled as a percentage
Some drugs may be labelled in different ways to those used earlier.

V/V and W/V
Some drugs may have V/V or W/V on the label.
V/V means that the percentage on the bottle corresponds to volume of drug per volume of solution i.e 15% V/V means for every 100ml of solution, 15ml is the drug.
W/V means that the percentage on the bottle corresponds to the weight of drug **per volume** of solution. Normally this is of the form 'number of grams per number of millilitres'. So in this case 15% W/V means that for every 100ml of solution there are 15 grams of the drug.

If we are converting between solution strengths, such as diluting a 20% solution to make it a 10% solution, we do not need to know whether the solution is V/V or W/V.

Examples
5. We need to make up 1 litre of a 5% solution of A. We have stock solution of 10%. How much of the stock solution do we need? How much water do we need?

We can adapt the formula for liquid medicines here:

$$\frac{\text{What we want}}{\text{What we've got}} \times \text{What we want it to be in}$$

We want a 5% solution. This is same as 5/100 or 1/20.
We've got a 10% solution. This is the same as 10/100 or $\frac{1}{10}$.
We want our finished solution to have a volume of 1000ml. Our formula becomes: $\frac{(1/20)}{(1/10)} * 1000$

(using the rule for dividing fractions)

$= 1/2 \times 1000 = 500$.

We need 500mls of the A solution.

Which means we need 1000 - 500 = 500mls of water.

(Alternatively you can use the fact that a 5% solution is half the strength of a 10% solution to see that you need 500ml of solution and 500ml of water)

6. You have a 20% V/V solution of drug F. The patient requires 30ml of the drug. How much of the solution is required?

20% V/V means that for every 100ml of solution we have 20ml of drug F. Using our formula:

$$\frac{\text{What you want}}{\text{What you've got}} \times \text{What it's in}$$

This becomes $\frac{30}{20} \times 100 = 150$

We need 150mls of solution.

7. Drug G comes in a W/V solution of 5%. The patient requires 15 grams of G. How many mls of solution are needed?

5% W/V means that for every 100mls of solution, there are 5 grams of G. Using the

formula gives us

$\frac{15}{5} \times 100 = 300$

300mls of solution are required.

Other Dimensional analysis problem example:

(B) A person is driving a car with a speed of 229.8 km/h. What is the speed in

1) ***Miles per hour***
2) ***Feet per second***

Given 1 km= 0.6214 mile 1000m= 1km, 1 m= 3.28 ft, 60 sec=1min and 60 min= 1 hr

1) **Step#1: Identify given and target quantity and numbers:**

   Given: 229.8km/hr   target: mi/hr

   Step#2: Write the conversion factors:

   Provided in the problem: $\frac{0.6214 \text{ mi}}{1 \text{ km}}$

   Step#3. Multiply the given quantity by the conversion factor.

   $229.8 \cancel{\text{km}} \times \frac{0.6214 \text{ mi}}{1 \cancel{\text{km}}}$ = 143.4mi/hr (lowest 4 sig fig used in problem)

2) Step#1: Identify given and target quantity and numbers:

Given: 229.8km/hr target: ft/s

Step#2: Write the conversion factors:

Provided in the problem: $\frac{3.28\ \text{ft}}{1\ \text{m}}$ & $\frac{0.6214\ \text{mi}}{1\ \text{km}}$

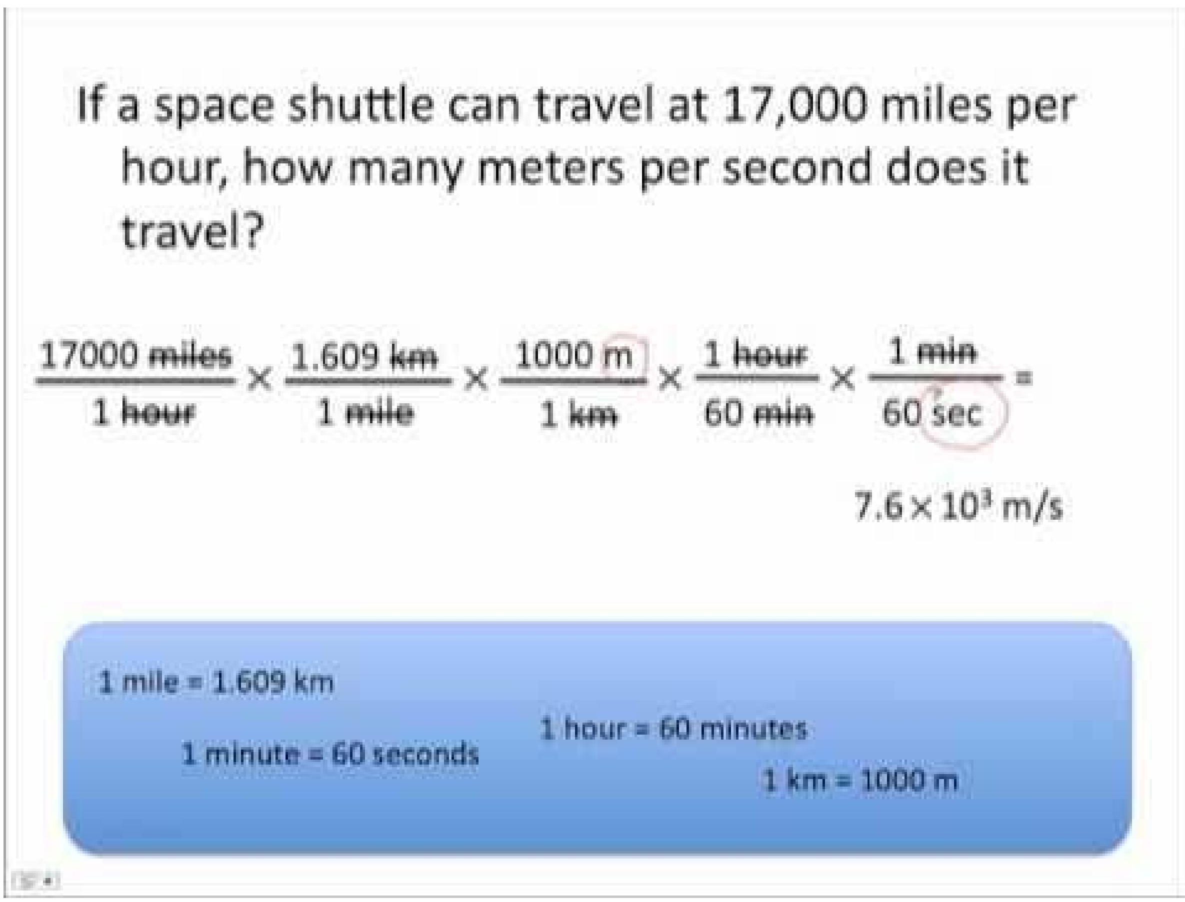
$\frac{1\ \text{hr}}{60\ \text{min}}$, $\frac{1\ \text{min}}{60\ \text{sec}}$

Step#3. Multiply the given quantity by the conversion factor.

$$\frac{229.8\ \cancel{\text{km}}}{1\ \cancel{\text{hr}}} \times \frac{1000\cancel{\text{m}}}{1\ \cancel{\text{km}}} \times \frac{3.28\ \text{ft}}{1\ \cancel{\text{m}}} \times \frac{1\ \cancel{\text{hr}}}{60\ \cancel{\text{min}}} \times \frac{1\ \cancel{\text{min}}}{60\ \text{sec}}$$

= 209 ft/s (lowest 3 sig fig used in calc).

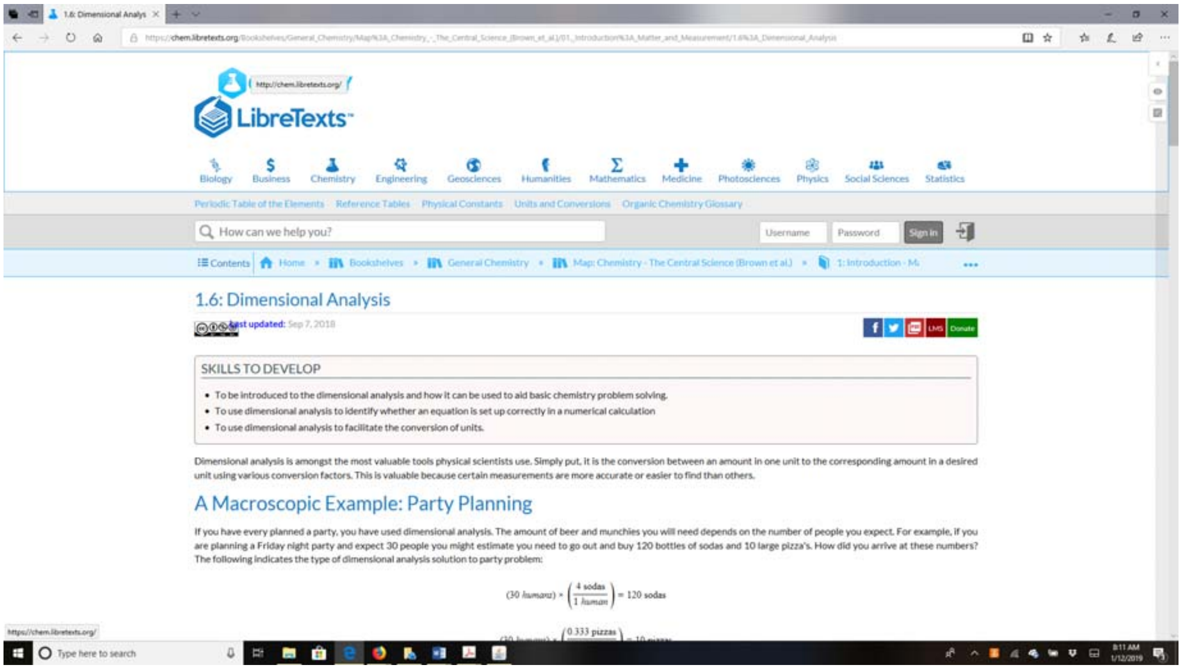
<u>For more information watch this out:</u>



https://www.youtube.com/watch?v=DsTg1CeWchc

For more practice visit:

https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_Chemistry_-_The_Central_Science_(Brown_et_al.)/01._Introduction%3A_Matter_and_Measurement/1.6%3A_Dimensional_Analysis



Questions:

1. How many milliliters of Children's Mortin (100 mg of ibuprofen per 5 ml) are needed to give a child a dose of 180 mg?

2. A patient is prescribed 0.150mg of a drug that is available in 25 µg tablets. How many tablets are needed?

3. If one teaspoon contains 5.0 ml, how many teaspoons of Children Tylenol (100. mg of acetaminophen per 2.5 ml) are needed for a child with a dose of 240 mg?

Ans: 1. 9 ml
2.6 tablets
3. 1.2 teaspoon

Chapter Objectives

For more practice: Go to the following website for online tutorial on Unit Conversion:

http://joneslhs.weebly.com/

Unit Conversion Tutorial

Go to the following website: **http://joneslhs.weebly.com**

- Click on the **Learn** button on the left. Read the tutorial first. When you think that you understand the idea, go back to the Main Menu and click on **One Step Conversions**.

One Step Conversions

- For problems 1, 2, and 3 write down what the completed problem looks like. Cancel the units that cancel. Circle the unit that doesn't cancel. Write down the answer to the problem.

1. =

2. =

3. =

For problems 4-9, you can just write down the answer once you have solved it.

4. Calculated Answer:
5. Calculated Answer:
6. Calculated Answer:
7. Calculated Answer:
8. Calculated Answer:
9. Calculated Answer:

For problem 10, solve it on paper here. Then type in the calculated answer to see if you are correct.

10. Solved problem and answer:

WHEN YOU ARE DONE, SHOW YOUR WORK TO YOUR INSTRUCTOR BEFORE MOVING ON TO A MORE CHALLENGING LEVEL.

Multi-Step Conversions

Name: ______________________________

- For problems 1, 2, and 3 write down what the completed problem looks like. <u>Cancel the units that cancel</u>. Circle the unit that is the one left at the end. Write down the answer to the problem.

1.

=

2.

=

3.

=

For problems 4-10, you can just write down the answer once you have solved it.

4. Calculated Answer:
5. Calculated Answer:
6. Calculated Answer:
7. Calculated Answer:
8. Calculated Answer:

9. Calculated Answer:

For problem 10, solve it on paper here. Then type in the calculated answer to see if you are correct.

10. Solved problem and answer:

WHEN YOU ARE DONE, SHOW YOUR WORK TO YOUR INSTRUCTOR BEFORE MOVING ON TO A MORE CHALLENGING LEVEL.

Name: ___________________________________

Double Unit Conversions

- Read the directions on the first problem to see how to get started. Work through the challenging problems recording your answer for each one. Don't forget <u>units</u>!

1. Calculated Answer:
2. Calculated Answer:
3. Calculated Answer:
4. Calculated Answer:
5. Calculated Answer:
6. For problem 6, solve it on paper here. Then type in the calculated answer to see if you are correct.

Cubed and Squared Conversions

- Read the directions on the first problem to see how to get started. Work through the challenging problems recording your answer for each one. Don't forget <u>units</u>!

1. Calculated Answer:
2. Calculated Answer:

3. Calculated Answer:
4. For problem 4, solve it on paper here. Then type in the calculated answer to see if you are correct.

The following classroom resources has been taken from AACT.

Cupcake Conversions, from Bench to Bakery

Background
All consumer products start as a small batch to formulate ideal qualities but are scaled up to mass production for consumer purchase. In this process troubleshooting is essential to maintain quality and consistency of product.

You will take on the role of a successful baker who has an award winning recipe for cupcakes which is going to be scaled up to commercial baking. To achieve this end goal you will look at conversions from English units to Metric units and then standardize all units to grams regardless of ingredients. Finally you will look at issues on a microscale of production and see how they would affect macroscale baking of the product.

Objectives
- Convert measurements from English to the International Units of Measurement (Metric).
- Scale up measurements for a standard recipe to a larger quantity.
- Trouble shoot problems encountered with scaling up a product from bench to bakery (small to larger quantities).

Activity 1
1. Read the recipe for a vanilla cupcake below:

Vanilla Cupcakes
The following recipe yields 20-25 cupcakes.

Ingredients:
- 2 cups of flour
- ½ teaspoon of salt
- 2 teaspoons of baking powder
- ½ cup of unsalted butter, softened
- ¾ cup of sugar
- 2 eggs
- 1 cup of whole milk
- 1 teaspoon vanilla extract (optional)

Directions for baking:

- Preheat oven to 375ºF; line muffin cups with papers.
- Beat and mix butter and sugar until it becomes a light and fluffy homogenous mixture. Beat in eggs one at a time.
- Mix baking powder, salt and flour.
- Add the flour mixture alternating with milk; beat well.
- Stir in the vanilla.
- Divide evenly among pans and bake for 18 minutes.
- Let cool in pans.

2. You live in a global society and you realize that this recipe should be out there for the rest of the world. Unfortunately, the rest of the world (except for the United States, Liberia and Myanmar) doesn't use the English Standard of measurement. They all use the International System of Measurement, or the Metric scale. Please convert each of the measurements below from English Standard to Metric.

   a. How many grams are in 2 cups of wheat flour if 1 cup is 120.00 grams? Remember to use dimensional analysis to solve this problem.

      Example:
      Starting unit x Conversion = Answer

      $$\frac{2.00\ \cancel{\text{Cups of Flour}}}{1.00\ \cancel{\text{Cup of Flour}}} \times \underline{120.00\ \text{grams}} = 240.\ \text{g}$$

      Note that the units are cancelled because anything divided by itself is the value of 1.00.

   b. How many grams are in ½ teaspoon of salt if 5.00 grams of salt are in 1.00 teaspoon?

   c. How many grams are in 2 teaspoons of baking powder if 4.60 grams of baking powder are in 1.00 teaspoon?

   d. How many grams are in ½ cup of unsalted butter if there are 227.00 grams of butter in 1.00 cup?

e. How many grams of sugar are in ¾ cup of sugar if there are 200.00 grams of sugar in 1.00 cup?

f. What is the mass of 2 eggs if the mass of an average egg is 2.00 ounces? There are 28.50 grams per ounce. You must first convert from the number of eggs to ounces and then the number of ounces to grams.

g. How many grams of milk are in 1 cup of milk if there are 473.176 mL of milk in 2.00 cups and the density of milk is 1.027 grams/mL? You must first convert the cups of milk to milliliters and then convert milliliters to grams using the density. Remember use dimensional analysis.

h. How many grams of vanilla extract are in 1 teaspoon vanilla extract if 1.00 teaspoon is 0.15 fluid ounces and 1.00 fluid ounce is 28.35 grams? You must first convert the teaspoon to fluid ounces and then the fluid ounces to grams. Remember to use dimensional analysis.

i. Convert the baking temperature of 375 ^{o}F to Celsius.
    a. Why Celsius? Watch the Temperature Guys video to understand the difference between the two scales.

    b. Use the following formula for the conversion:
    $T_{(°C)} = (T_{(F)} - 32) \times 5/9$

j. Successful bakeries don't just make one batch of anything. In order to be competitive this recipe must be scaled up. How much of each ingredient would be required to make 200 cupcakes? Fill in the table below with your scale up information.

Ingredients	Amount Calculated (g) for Single Batch or 24 Cupcakes	Amount Calculated (g) for 8.33 Batches or 200 Cupcakes
Flour		
Salt		
Baking Powder		
Unsalted Butter		
Sugar		
Eggs		
Milk		
Vanilla Extract		

Activity 2

Scaling up is not as simple as taking the basic ingredients and then multiplying by a factor to get the total quantity. So many variables can affect the outcome.

1. Using the graphic organizer below, brainstorm at least three issues that could arise when baking cupcakes (i.e. what could go wrong) at the micro-level (home/test kitchen).

Heating	Ingredients	Mixing	Pan Selection

2. Using the graphic organizer below, brainstorm at least three issues that could arise when baking cupcakes (i.e. what could go wrong) at the macro-level (commercial bakery).

Heating	Ingredients	Mixing	Pan Selection

3. Share your thoughts with at least one other person in class. Fill in ideas that you didn't have in your graphic organizer.

4. Be prepared to share your ideas during the teacher lead discussion.

5. Answer the following questions:
   a. After listening to other students and watching the slide show summarize your findings in a concise set of directives to the bakery manager to:
      i. Ensure that the final product (the 200 cupcakes) maintains its quality and consistency.
      ii. Provide the final recipe, in grams, to the bakery manager.

   b. Putting yourself in the role of the bakery manager explain why you will still need to do testing to ensure quality control.

Answer Key: Cupcake Conversions, from Bench to Bakery

**Note that not all answers are calculated using significant digits.*

Activity 1

3. Read the recipe for a vanilla cupcake below:

Vanilla Cupcakes The following recipe yields 20-25 cupcakes.

Ingredients:

- 2 cups of flour
- ½ teaspoon of salt
- 2 teaspoons of baking powder
- ½ cup of unsalted butter, softened
- ¾ cup of sugar
- 2 eggs
- 1 cup of whole milk
- 1 teaspoon vanilla extract (optional)

Directions for baking:

- Preheat oven to 375ºF; line muffin cups with papers.
- Beat and mix butter and sugar until it becomes a light and fluffy homogenous mixture. Beat in eggs one at a time.
- Mix baking powder, salt and flour.
- Add the flour mixture alternating with milk; beat well.
- Stir in the vanilla.
- Divide evenly among pans and bake for 18 minutes.
- Let cool in pans.

4. You live in a global society and you realize that this recipe should be out there for the rest of the world. Unfortunately, the rest of the world (except for the United States, Liberia and Myanmar) doesn't use the English Standard of measurement. They all use the International System of Measurement, or the Metric scale. Please convert each of the measurements below from English Standard to Metric.

   k. How many grams are in 2 cups of wheat flour if 1 cup is 120.00 grams? Remember to use dimensional analysis to solve this problem.

   Example:
   Starting unit x Conversion = Answer

   2.00 ~~Cups of Flour~~ x 120.00 grams = 240. g
   1.00 ~~Cup of Flour~~

   Note that the units are cancelled because anything divided by itself is the value of 1.00.

   l. How many grams are in ½ teaspoon of salt if 5.00 grams of salt are in 1.00 teaspoon?

   0.5 ~~teaspoons of salt~~ x 5.00 grams = 2.50 g
   1.00 ~~teaspoons of salt~~

m. How many grams are in 2 teaspoons of baking powder if 4.60 grams of baking powder are in 1.00 teaspoon?

$$\frac{2.00\ \cancel{\text{teaspoons of baking powder}}}{1.00\ \cancel{\text{teaspoons of baking powder}}} \times \frac{4.60\ \text{grams}}{} = 9.20\ g$$

n. How many grams are in ½ cup of unsalted butter if there are 227.00 grams of butter in 1.00 cup?

$$\frac{0.50\ \cancel{\text{Cups of butter}}}{1.00\ \cancel{\text{Cup of butter}}} \times \frac{227.00\ \text{grams}}{} = 113.5\ g$$

o. How many grams of sugar are in ¾ cup of sugar if there are 200.00 grams of sugar in 1.00 cup?

$$\frac{.75\ \cancel{\text{Cups of sugar}}}{1.00\ \cancel{\text{Cup of sugar}}} \times \frac{200.00\ \text{grams}}{} = 150.00\ g$$

p. What is the mass of 2 eggs if the mass of an average egg is 2.00 ounces? There are 28.50 grams per ounce. You must first convert from the number of eggs to ounces and then the number of ounces to grams.

$$\frac{2\ \cancel{\text{eggs}}}{1\ \cancel{\text{egg}}} \times \frac{2.00\ \cancel{\text{ounce}}}{1\ \cancel{\text{ounce}}} \times \frac{28.50\ \text{grams}}{} = 114\ g$$

q. How many grams of milk are in 1 cup of milk if there are 473.176 mL of milk in 2.00 cups and the density of milk is 1.027 grams/mL? You must first convert the cups of milk to milliliters and then convert milliliters to grams using the density. Remember use dimensional analysis.

$$\frac{1\ \cancel{\text{cup of milk}}}{2\ \cancel{\text{cups of milk}}} \times \frac{473.176\ \cancel{\text{mL}}}{1\ \cancel{\text{mL}}} \times \frac{1.027\ \text{grams}}{} = 242.98\ g$$

r. How many grams of vanilla extract are in 1 teaspoon vanilla extract if 1.00 teaspoon is 0.15 fluid ounces and 1.00 fluid ounce is 28.35 grams? You must first convert the teaspoon to fluid ounces and then the fluid ounces to grams. Remember to use dimensional analysis.

$$\frac{1\ \cancel{\text{tsp vanilla}}}{1\ \cancel{\text{tsp}}} \times \frac{0.15\ \cancel{\text{fl. ounce}}}{1\ \cancel{\text{fl. ounce}}} \times \frac{28.35\ \text{grams}}{} = 4.25\ g$$

s. Convert the baking temperature of 375 °F to Celsius.

   a. Why Celsius? Watch the Temperature Guys video to understand the difference between the two scales.

   b. Use the following formula for the conversion:
   $T_{(°C)} = (T_{(F)} - 32) \times 5/9$

190.5 °C

t. Successful bakeries don't just make one batch of anything. In order to be competitive this recipe must be scaled up. How much of each ingredient would be required to make 200 cupcakes? Fill in the table below with your scale up information.

Ingredients	Amount Calculated (g) for Single Batch or 24 Cupcakes	Amount Calculated (g) for 8.33 Batches or 200 Cupcakes
Flour	240	2000
Salt	2.50	20.83
Baking Powder	9.20	76.67
Unsalted Butter	113.5	945.83
Sugar	150.00	1250
Eggs	114	950
Milk	242.98	2024.83
Vanilla Extract	4.25	35.42

Activity 2

Scaling up is not as simple as taking the basic ingredients and then multiplying by a factor to get the total quantity. So many variables can affect the outcome.

6. Using the graphic organizer below, brainstorm at least three issues that could arise when baking cupcakes (i.e. what could go wrong) at the micro-level (home/test kitchen). Answers will vary, refer to PPT.

Heating	Ingredients	Mixing	Pan Selection

7. Using the graphic organizer below, brainstorm at least three issues that could arise when baking cupcakes (i.e. what could go wrong) at the macro-level (commercial bakery). Answers will vary, refer to PPT.

Heating	Ingredients	Mixing	Pan Selection

8. Share your thoughts with at least one other person in class. Fill in ideas that you didn't have in your graphic organizer.

9. Be prepared to share your ideas during the teacher lead discussion.

10. Answer the following questions:
    c. After listening to other students and watching the slide show summarize your findings in a concise set of directives to the bakery manager to:
        i. Ensure that the final product (the 200 cupcakes) maintains its quality and consistency.
        ii. Provide the final recipe, in grams, to the bakery manager.

    Answers will vary, some possibilities inclue:
    - Production baker needs to calibrate ovens.
    - Production baker might have different equipment so it will be different at larger scales so he/she will still need to trouble shoot batches of cupcakes.
    - He/she should change variables, collect data, and send the results back to the original baker so that trouble shooting can occur back at the micro level. This is what happens in industry with product development.

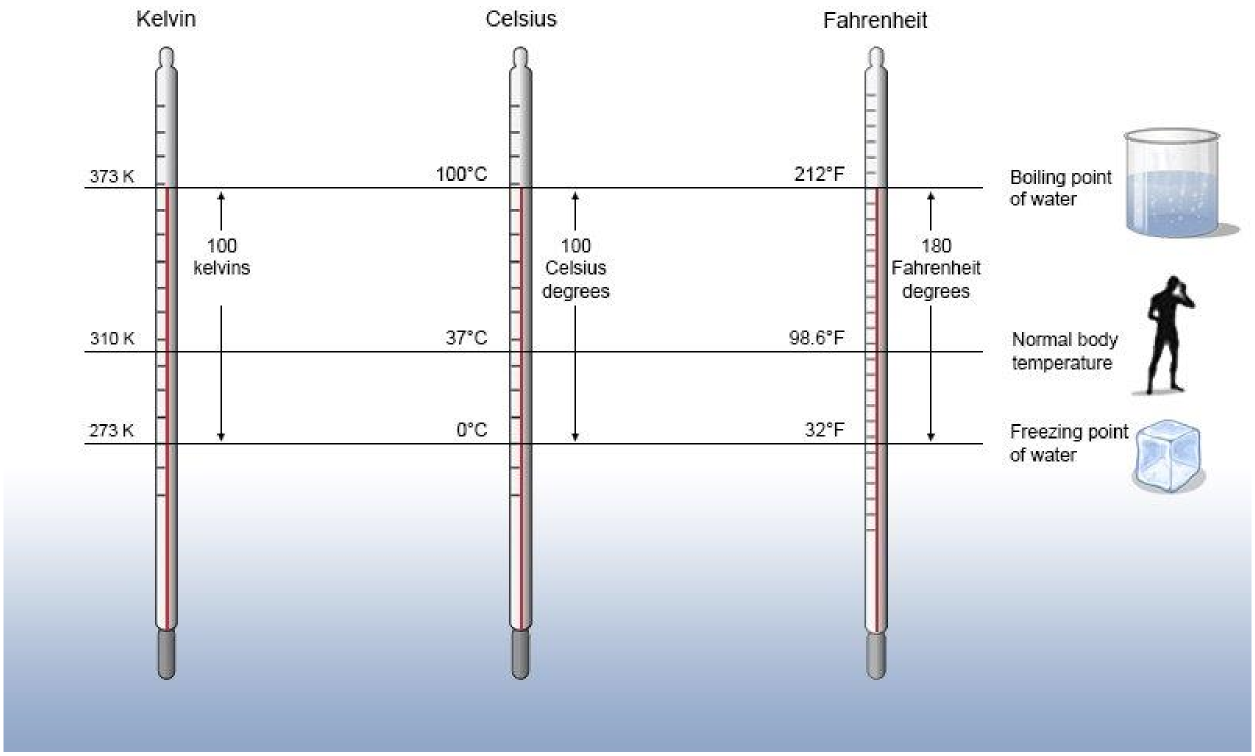
d. Putting yourself in the role of the bakery manager explain why you will still need to do testing to ensure quality control.

XV. Temperature

Temperature is a measure of how hot or cold object is. It is defined as measure of average kinetic energy of the particle. In scientific world,
three Temperature scales are used. Fahrenheit, Celcius and Kelvin.

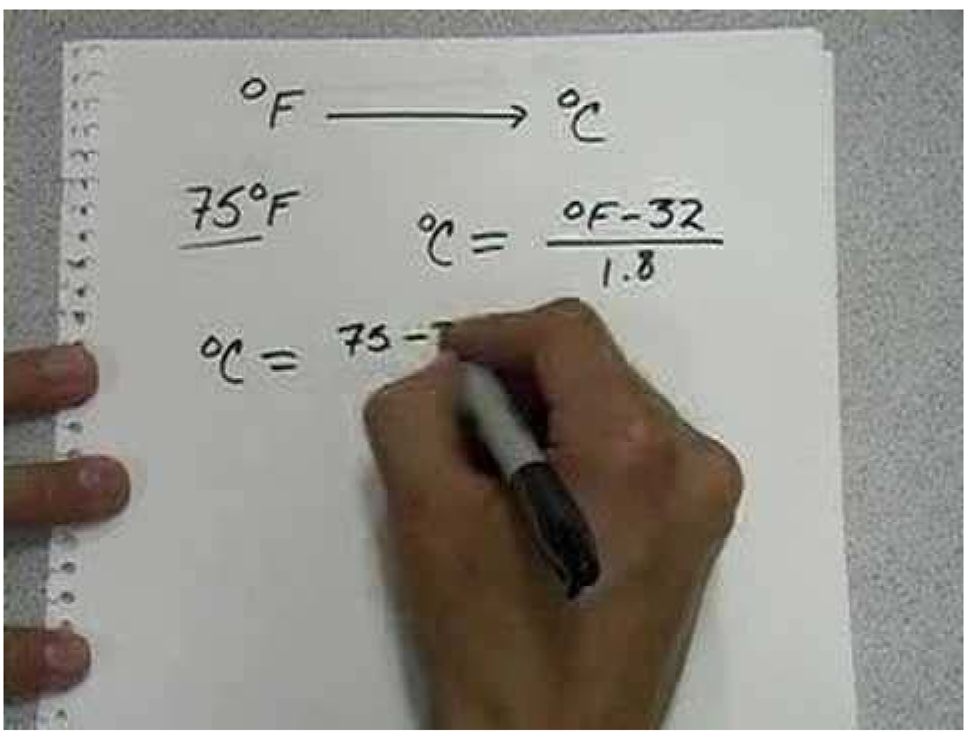
$T_f = 1.8Tc + 32$ $\qquad$ $Tk = Tc + 273$

-273.15 degree celcius is defined as absolute zero temperature. This is the lowest possible temperature theoretically possible in this universe. As temperature decreases, all energy of matter decreases as degrees of molecular and atomic motion decreases. A matter is expected to have all motion frozen at absolute zero temperature.



Watch the following video:

https://www.youtube.com/watch?v=9sEnXM3WeZk



Example Problem:
State the Temperature on the Celcius Thermometer and convert into Fahrenheit scale.

Celcius: 61.5^{o}C
Applying the formula: Tf= 1.8Tc+ 32
1.8*61.5 +32= 142.7= 143^{o}F
Applying the formula: Tf= 1.8Tc+ 32
155=1.8Tc +32
155-32= 1.8Tc,
1.8Tc=123
Tc= 68.3 oC
Tk= Tc+273= 341.3K

Questions:

1. Why is the number 1.8 (and not some other value) used in the formula for converting between Celsius and Fahrenheit temperatures?

2. Convert the following Farenheit temperature into celcius and kelvin
   a. 12^{0}F
   b. 32^{0}F
   c. -40^{0}F
   d. 212^{0}F

Ans: 1. Since the ratio of calibration between two scales is 180/100= 1.8

2.a) -11^{0}C and 262.15 K
b) 0^{0}C and 273 K
c) -40^{0}C and 233 K
d) 100^{0}C and 373K

Chapter Objectives

XVI. Density

What do you observe in the above picture? Why?
Answer: Ice floating in water; Density

Density is a physical property that relates the mass of a substance to its volume. Density is defined as mass per unit volume of a substance. Density is reported as g/ml or g/cc. The mathematical form of density d= m/v. Physical meaning of density refers to the compactness of the substance.
Density of a substance depends on temperature. Specially for liquids and gases, when temperature increases, volume expands and therefore density decreases. For most substances solid state is denser than liquid and liquid is more dense than gas. Water is an exception. Ice is less dense than liquid water. A less dense substance floats on a denser liquid.
Density also depends on pressure. An allotrope of carbon Diamond can be converted to graphite at a very high pressure. Although they contain the same atoms of carbon but they do not share the same density.

If two liquids are mixed together and they are immiscible, liquid with lower density is always on top of liquid with higher density. In other words, substance with higher density always sinks in substance with lower density and vice versa.

Densities of Common Substances

Material	Density (gm/cm^3)
Liquids	
Water at 4 C	1.0000
Water at 20 C	0.998
Gasoline	0.70
Mercury	13.6
Milk	1.03
Material	Density (gm/cm^3)
Solids	
Magnesium	1.7
Aluminum	2.7
Copper	8.3-9.0
Gold	19.3
Iron	7.8
Lead	11.3
Platinum	21.4
Uranium	18.7
Osmium	22.5
Ice at 0 C	0.92
Material	Density (gm/cm^3)
Gases at STP	
Air	0.001293
Carbon dioxide	.001977
Carbon monoxide	0.00125
Hydrogen	0.00009
Helium	0.000178
Nitrogen	0.001251

http://hyperphysics.phy-astr.gsu.edu/hbase/Tables/density.html

There are two different ways density can be determined in Lab. 1) dimensional method and 2) displacement method.

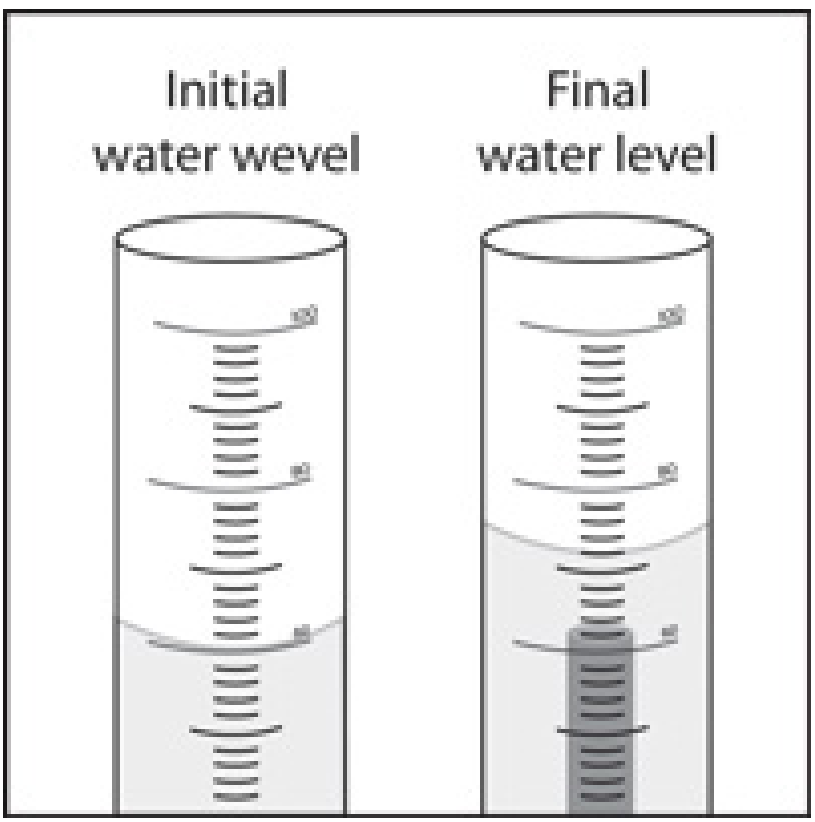
In dimensional method, volume of the regularly shaped object is determined applying the standard formula. Mass of the object is determined using analytical balance. Then mass is divided by volume to determine the density.

Example: Determine the density of a unknown metal cube that has side length 3.00cmand mass is 310.672g.

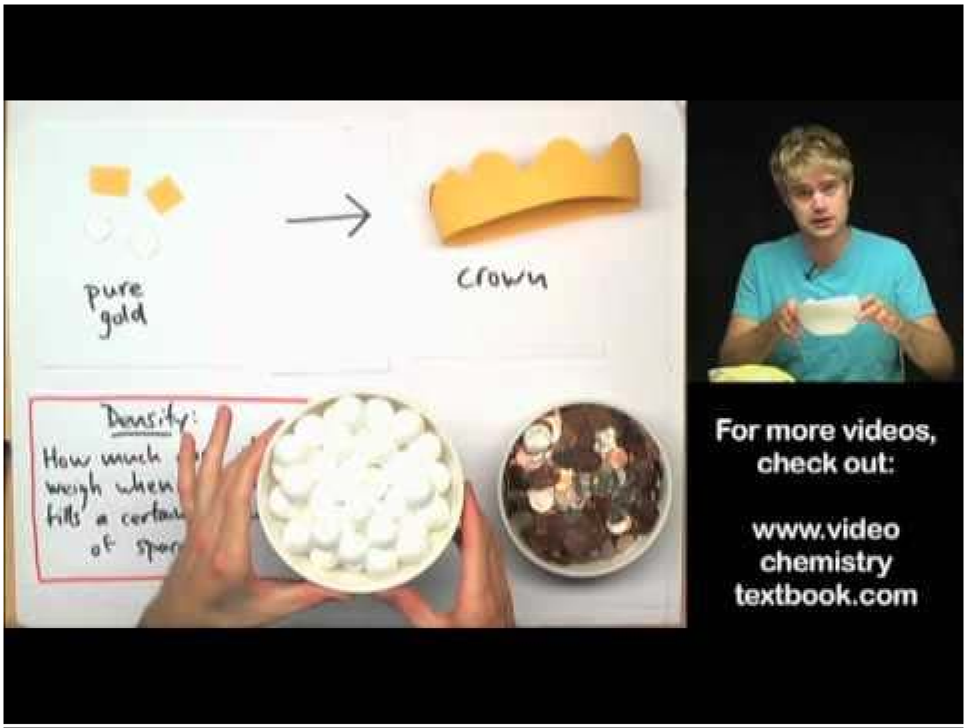
Volume of the metal cube 3.00*3.00*3.00= 27.0 cm^3

Density of the metal= 310.671/27.0= 11.5 g/cm^3

In displacement method some water is taken in the graduated cylinder and then the irregular shaped object is dropped in the cylinder. Volume of water in the cylinder rises. The difference in volume between initial and final volume of graduated cylinder is the volume of the cylinder.



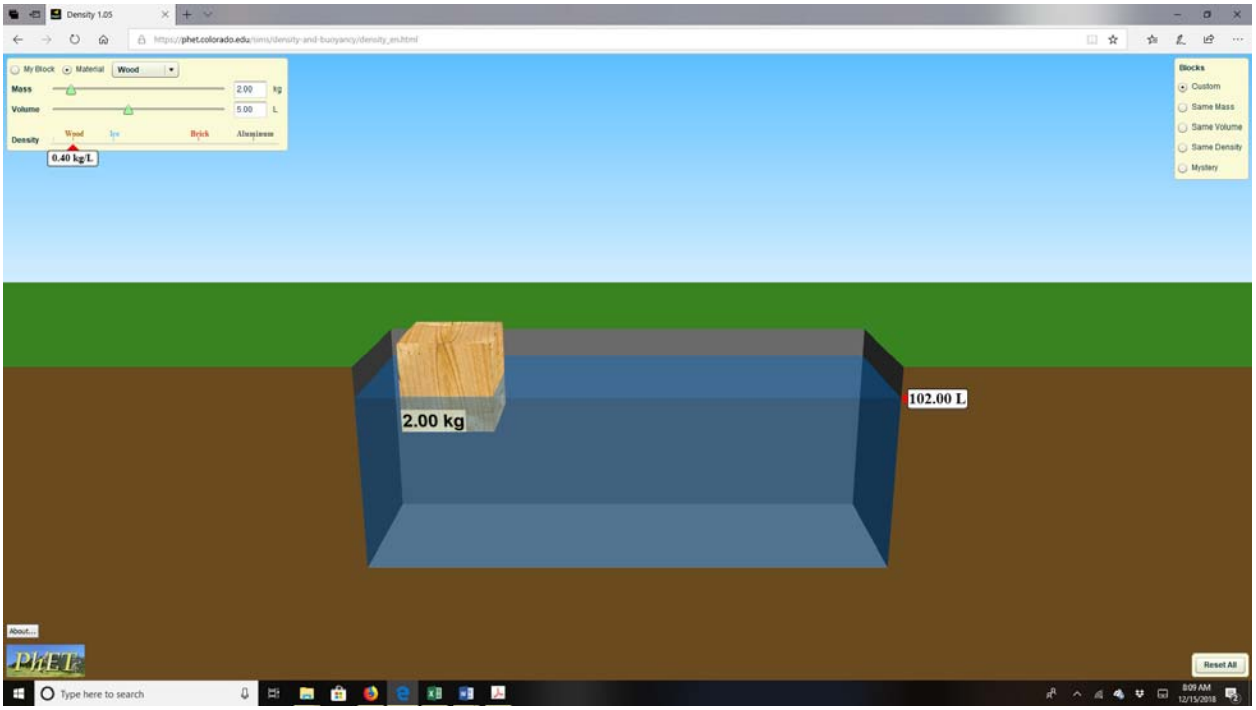
In the above example, volume of the liquid (96.0-90.0)ml =6.0 ml.
If the mass of the sample 16.9050g, the density of the sample = 16.9050/6.0 ml= 2.8 g/ml.



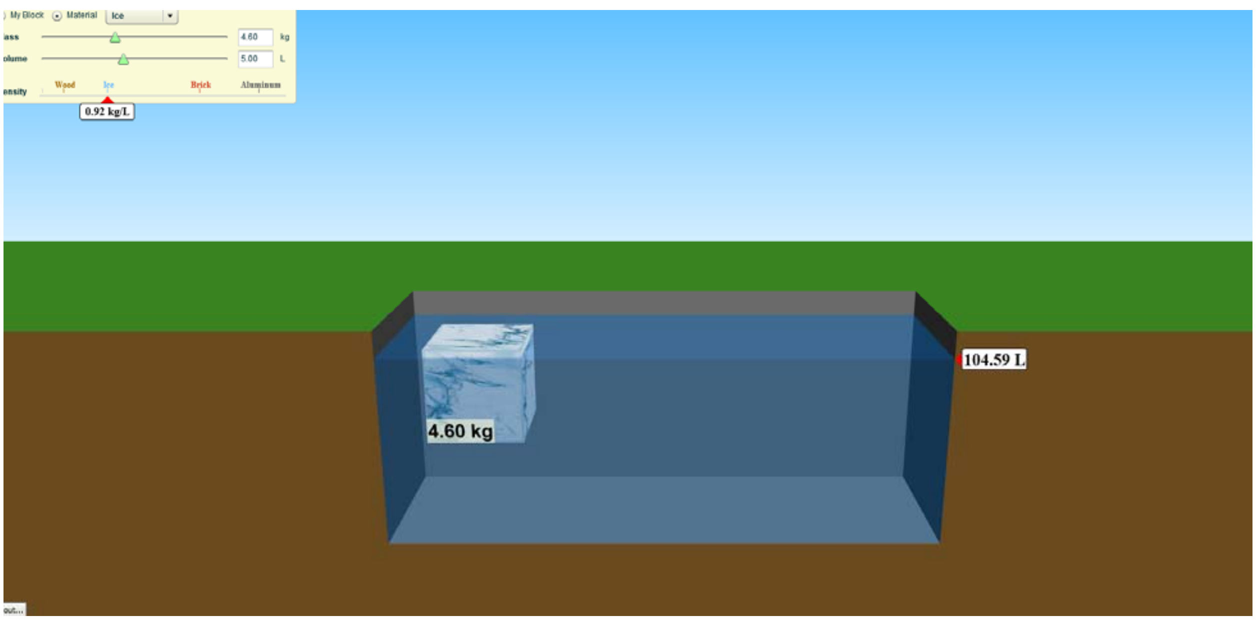
https://www.youtube.com/watch?v=KMNwXUCXLdk

TRY THIS OUT! (you need Adobe Flash to run this application)
https://phet.colorado.edu/en/simulation/legacy/density

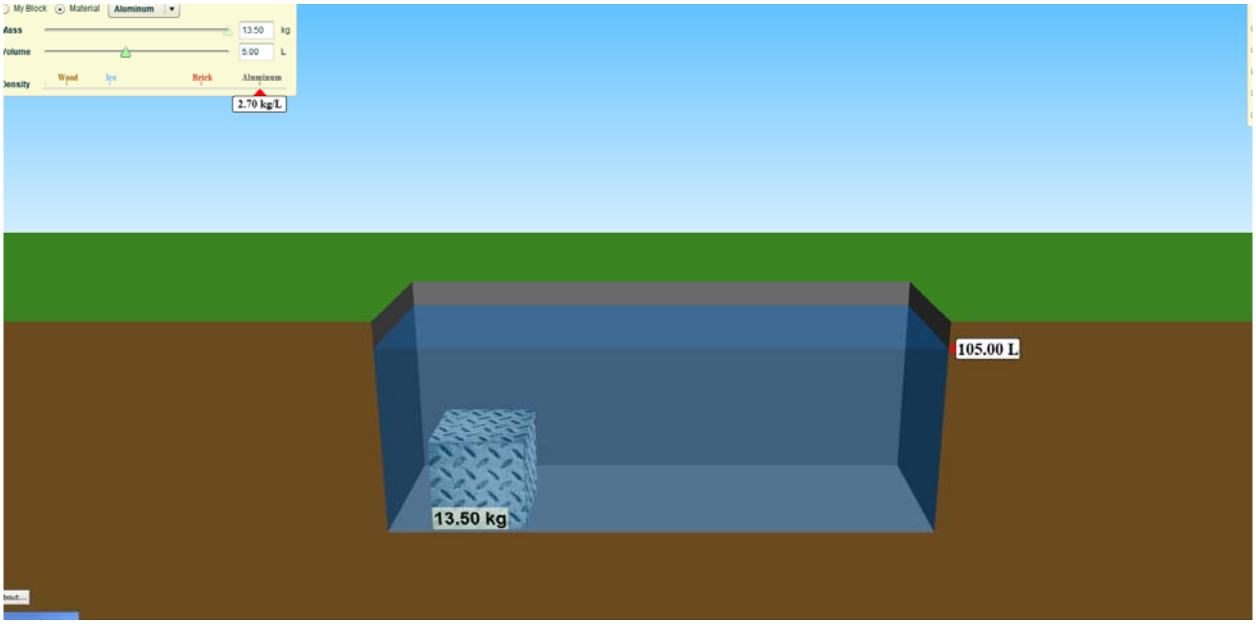
Block#1: Wood



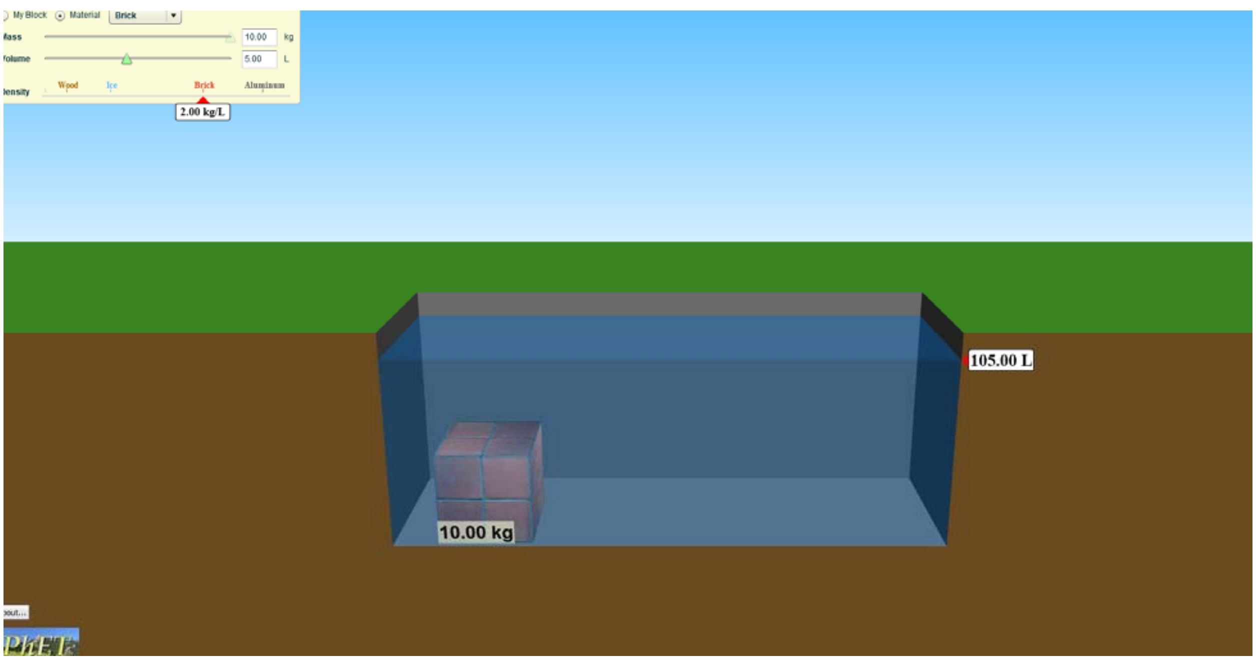
Block#2: Ice



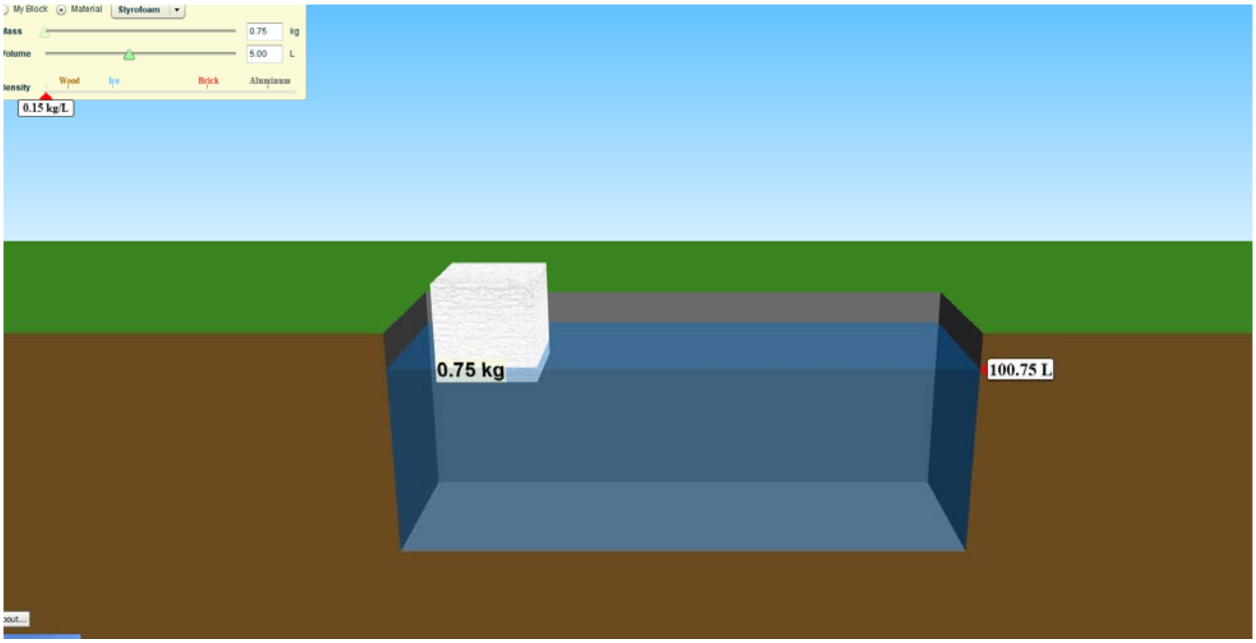
Block#3: Aluminum



Block#4: Brick



Block#5: Styrofoam



Activity:

1) Select each custom block and record mass, volume and density of each block.
2) Click on the "my block" and determine the density.
3) Convert the above density in g/cm^3. Does the value change?
4) Place each one of them in water. What do those blocks do in water?
5) Does your observation depend on the mass/volume ratio?
6) Would it be different if the liquid in the tank were ethanol instead of water?

Ans: 1) Wood m= 2.00kg, v= 5.00L; d= 0.400kg/L, Brick = 10.00/5.00=2.00kg/L, Ice 4.60/5.00 kg/L, Aluminum= 13.50/5.00= 2.70 Kg/L

2) density of my block 13.50/5.00= 2.70 Kg/L

3) same

4) Some sink and some float

5) Yes, if the mass/volume ratio>1 , sinks, if the ratio<1, float

6) Yes. Ethanol has different density than water. Less dense object floats, denser object sinks.

Example problem:

1. Calculate the density of Aluminum block with mass 13.4958g and volume 4.98 cm^3.

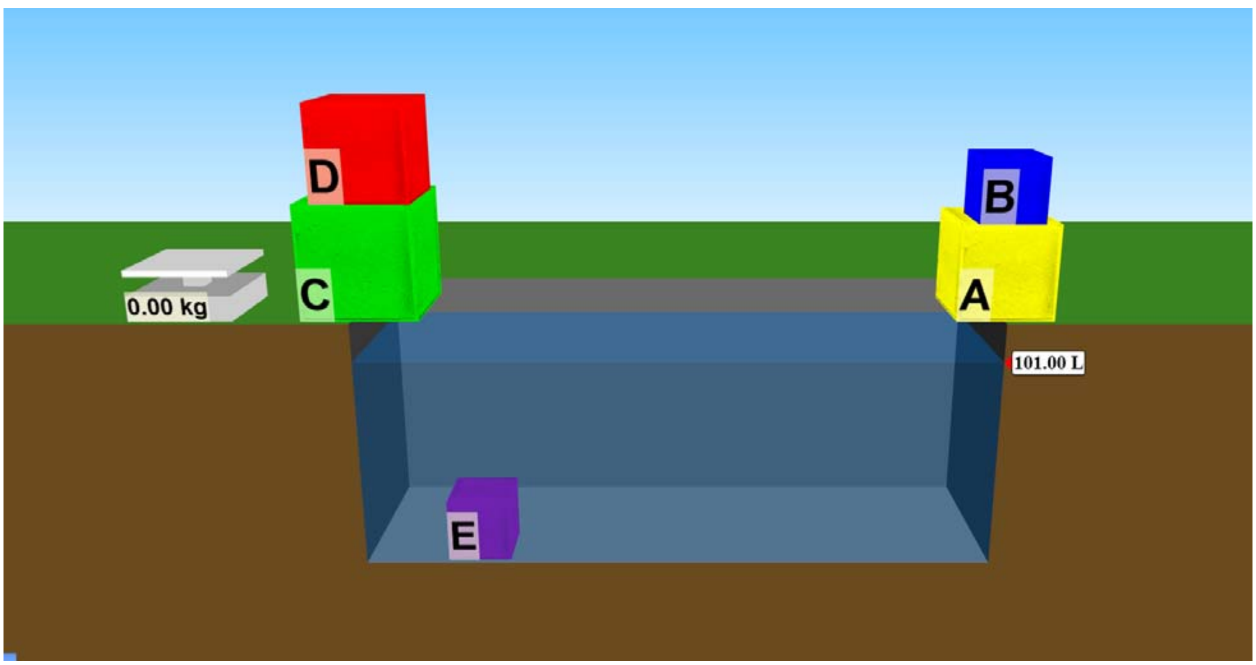
   D= m/v= 13.4958/4.98= 2.71 g/cm^3

2. What is the volume of 25 g copper that has density 8.90 g/ml?
   Density can be written as conversion factor.

   8.90 g/1 ml or 1 ml/8.90 g Since we have to determine volume, volume will be the numerator of the ratio.

   1 ml/8.90 g * 25 g = 2.8 ml (lowest sig fig 2)

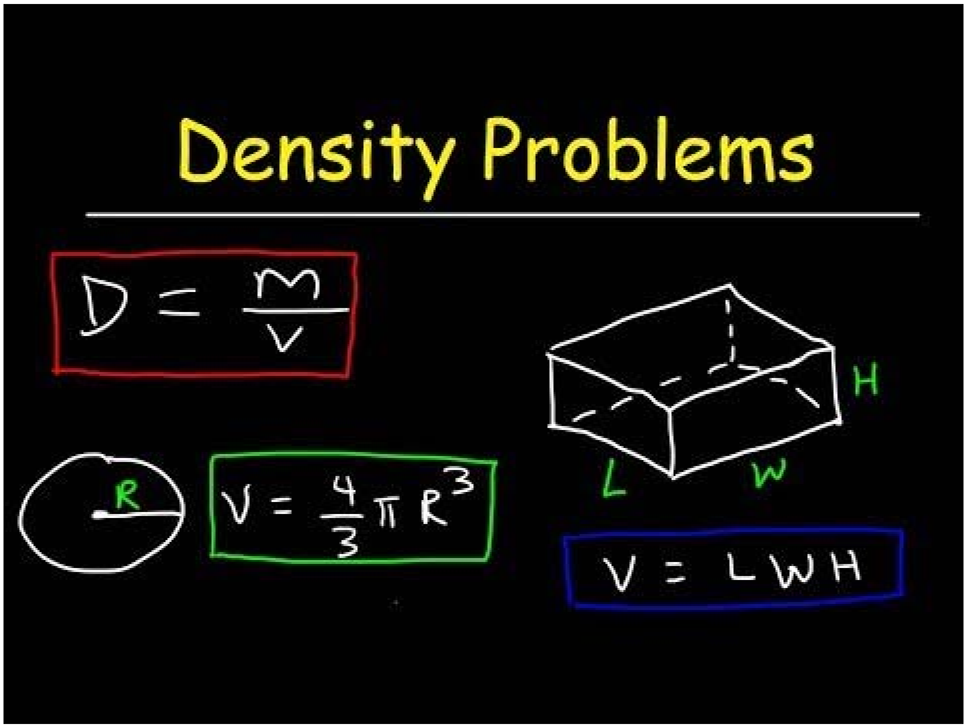
Click on the right hand side of the screen and mystery metal. Find the mass and volume of the sample by displacement method, determine the density. Can you identify which metal is this?



Watch the following videos:

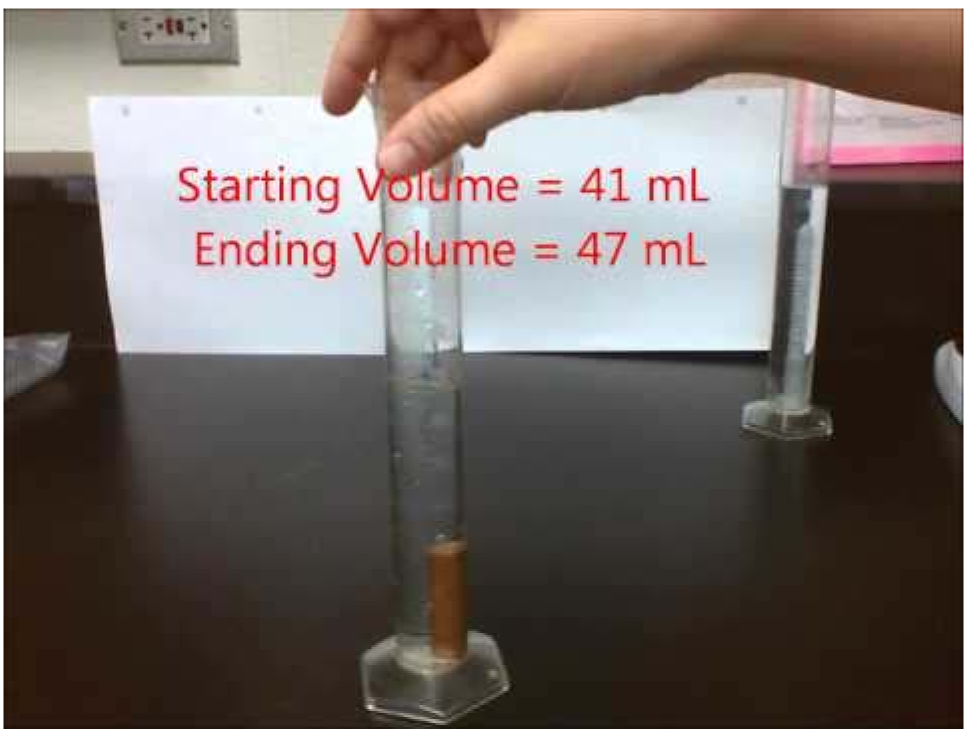
Dimensional method:

https://www.youtube.com/watch?v=9CKDQE35qXQ



Displacement method

https://www.youtube.com/watch?v=k7sVz8wcnWs



Questions:

1. The given beaker contains 100 ml of water. Draw an illustration for what would be observed in each circumstances when the following liquids were added. a) Hexane 50.0ml d= 0.65 g/ml b) dichloromethane 50.0ml d=1.33 g/ml.

2. Gasoline has a density of about 0.65 g/mL. How much does 36.0 L weigh in pound.

Ans: 1. See your instructor

2. 51.9 lb

Combined Dimensional Analysis Practice Problems

1. Convert 3.55 liters into milliliters.

2. Convert 1.64 pounds to grams and milligrams.

3. Convert 7.2 meters to centimeters and inches.

4. Convert 16,450 milligrams to grams and pounds.

5. Convert 12.0 feet into centimeters and meters.

6. Convert 1.500 days into minutes and seconds.

7. The highest temperature recorded in Washington D.C. was 106°F on July 20, 1930. Convert the temperature to °C and K.

8. On the 4th of July, a sparkler burns at a temperature of 1644K. Convert the temperature to both °C and °F.

9. I like my steak cooked medium rare – which means it will have an internal temperature of 135°F. Convert this temperature to °C and K.

10. A student finds a rock on the way to school. In the laboratory he determines that the volume of the rock is 22.7 cm^3, and the mass in 39.943 g. What is the density of the rock?

11. Calculate the density of a material that has a mass of 52.457 g and a volume of 13.5 cm^3.

12. The density of zinc is approximately 7.13 g/mL.

7.13 g Zinc=1 mL Zinc $$\frac{\textbf{7.13 g Zinc}}{\textbf{1 mL Zinc}} = \mathbf{1} = \frac{\textbf{1 mL Zinc}}{\textbf{7.13 g Zinc}}$$

   a. What is the volume, in cm^3, of a 5.00 g piece of zinc?

   b. What is the mass of a 45.6 L block of zinc?

13. a. A sample of iron has a volume of 25.0 cm^3 has a mass of 174 grams. Calculate the density of iron.

b.What would be the mass of 15.0 of cm^3 iron?

c. What would be the volume of 1000. grams of iron?

Ans: 1. 3550ml

2. 744 g and 744000 mg

3. 720 cm and 283 in

4. 16.45g and 0.03627 lb

5. 56.7 cm and 0.567 m

6. 2160 min and 129600 sec

7. 41.1 ^{0}C and 314K

8. 1371 ^{0}C and 2500.^{0}F

9. 57.2 ^{0}C and 330K

10. 1.76 g/cm^3

11. 3.89 g/cm^3

12. a. 0.701 ml

b. 325000g

13. a. 6.96 g/cm^3

b. 104 g

c. 144 cm^3

SAMPLE QUESTIONS: Chapter 1

1. An object weighs 75.7 kg. What is the weight of this object expressed in the English system? [1 pound = 453.6 grams]

a. 16.7 pounds	b. 167 pounds

c. 343 pounds	d. 34.3 pounds

2. The law of conservation of energy states which of the following?

a. Kinetic energy is conserved.

b. Potential energy is conserved.

c. The sum of kinetic energy and potential energy is conserved.

d. all of the above

3. Which of the following is synonymous with “fact”?

a. a hypothesis

b. an observation which is reproducible

c. an observation which is not reproducible

d. none of these

4. Which of the following statements is true?

a. Both heat and temperature are forms of energy.

b. Neither heat nor temperature is a form of energy.

c. Heat is a form of energy, but temperature is not.

d. Temperature is a form of energy, but heat is not.

5. At the 2008 Olympics the Jamaican runner Usain Bolt ran the 200. meter dash in world record time of 19.30 seconds. What is this speed in miles per hour? [1 mile = 1.609 km]

a. 43.1 mph	b. 23.2 mph

c. 4.31 mph	d. 2.32 mph

6. How many kilometers (km) are there in 1 millimeter (mm)?

a. 1×10^{-12}	b. 1×10^{-6}

c. 1×10^{6}	d. 1×10^{12}

15. Which of the following is a form of potential energy?

a.chemical energy   b.nuclear energy

c.both a and b   d.neither a nor b

16. Which of the following is not an example of matter?

a.the air in your lungs

b.the blood in your arteries

c.the sunlight coming through the window

d.None, all of these are matter.

17. Which state of matter is highly compressible?

a.solid   b.liquid

c.gas   d.none of them

18. How many microliters (µL) are there in 1 liter (L)?

a. 1×10^{-12} b. 1×10^{-6}

c. 1×10^{6} d. 1×10^{12}

19. An intern made an error and gave a patient a dose of 500 µg rather than 500 mg of a drug. Which of the following is true?

a.The patient received an overdose by a factor of 1000.

b.The patient received an overdose by a factor of 100.

c.The patient received an underdose by a factor of 1000.

d.The patient received an underdose by a factor of 100.

20. Iron has a density of 7.874 g/cm^3. What is the volume of a block of iron which weighs 15.321 g?

a. 0.008289 cm^3 b. 0.5139 cm^3

c. 1.946 cm^3 d. 120.6 cm^3

21. Which of the following is not a form of kinetic energy?

a.chemical energy   b.electrical energy

c.light energy   d.mechanical energy

22. Given the calculation: 17.712/7.610 = ?, what is the answer reported to the correct number of significant figures?

a.2.32746   b.2.3275

c.2.327   d.2.33

23. How many calories of are required to heat 731 grams of water from 35°C to 83°C? (Assume that the specific heat of water is 1.00 cal/g·°C).

7. Which state of matter is essentially incompressible?

a.solid b.liquid

c.gas d.none of them

8. The specific heat of lead is 0.0380 cal/g·°C. If 47.0 calories of energy raised the temperature of a lead sample from 28.3°C to 30.1°C what is the mass of the sample?

a.26 g b.687 g

c.1.2×10^3 g d.2.3×10^3 g

9. The length of an American football field is 100. yards. Which of the following most nearly approximates the length of this field in meters? [1 meter is slightly longer than 39 inches]

a.9.14 m b.10.9 m

c.91.4 m d.109 m

10. At the 2008 Olympics the Jamaican runner Usain Bolt ran the 100. meter dash in world record time of 9.69 seconds. What is this speed in miles per hour?
[1 mile = 1.609 km]

a.2.31 mph b.4.33 mph

c.23.1 mph d.43.3 mph

11. Which of the following is true of a hypothesis?

a.It is a tentative idea or explanation which can be disproved by an experiment.

b.It is a tentative idea or explanation which can be proven by an experiment.

c.It is a tentative idea which can either be proven or disproved by an experiment.

d.It is a belief which is asserted without proof.

12. Given the calculation: 17.72 – 4.232 – 9.1 = ?, what is the answer reported to the correct number of significant figures?

a.4.388 b.4.38

c.4.39 d.4.4

13. Xenon is a gas found in some automobile headlights. The density of xenon at room temperature and pressure is 5.37 g/L. What is the mass, in pounds of 1.00 quart of xenon? [1 liter = 1.057 quart; 1 pound = 453.6 grams]

a.0.0112 lb b.0.0125 lb

c.79.9 lb d.89.3 lb

14. Iron has a density of 7.874 g/cm^3. What is the mass of a rectangular block of iron with dimensions of 3.000 cm by 4.000 cm by 5.000 cm?

a.7.629 g b.60.00 g

c.94.48 g d.472.4 g

a. 15 cal b. 7.3×10^2 cal

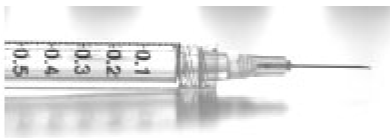
c. 2.6×10^4 cal d. 3.5×10^4 cal

24. In the SI system of units the basic unit of volume is the cubic meter (m^3). The cubic meter is equal to which of the following?

a. 10^3 mL b. 10^6 mL

c. 10^9 mL d. 10^{12} mL

25. Consider the following image:



Which of the following would be appropriate units to use when measuring with this piece of equipment?

a. L

b. mL

c. cm^3

d. either b or c

26. Which of the following is true about specific gravity of a material?

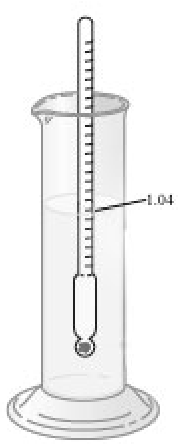
a. It has units of g/mL.

b. It is defined as the density of the material divided by the density of water.

c. both a and b

d. neither a nor b

27. Consider the urinometer shown used to make a measurement at 25 °C.



What is the density of the liquid shown at the same temperature?

a. 1.04
b. 1.04 g/mL
c. 0.962
d. 0.962 g/mL
e. The density cannot be determined from the given data.

28. Given the calculation: $(6.626 \times 10^{-34})/(9.63 \times 10^{7})$ = ?, what is the answer reported to the correct number of significant figures?

a. 1.453×10^{41} b. 1.45×10^{41}
c. 6.88×10^{-42} d. 6.882×10^{-42}

29. Which of the following represents a physical change?

a. boiling water b. decomposition of a dead organism
c. both a and b d. neither a nor b

30. How many minutes are in a 365 day year? [Assume exactly 24 hours in a day]

a. 8.760×10^{3} b. 2.190×10^{4}
c. 5.256×10^{5} d. 3.154×10^{7}

31. The specific heat of copper is 0.092 cal/g·°C. How much energy is required to heat 40.0 grams of copper from 25.0°C to 75.0°C?

a. 92 cal b. 184 cal
c. 2.0×10^{2} cal d. 280 cal

32. The decimeter (dm) is 0.1 m. Sometimes the volume of a liquid is specified in units of cubic decimeters. Which of the following volumes equals 1 cubic decimeter?

a. 10μL b. 10 mL
c. 100 mL d. 1000 mL

33. How many calories of are required to heat 139 grams of water from 15°C to 88°C? (Assume that the specific heat of water is 1.00 cal/g·°C).

a. 73 cal b. 2.1×10^{4} cal
c. 1.0×10^{4} cal d. 1.2×10^{4} cal

34. A certain automobile has an 18 gallon gas tank. What is the volume of this tank in liters? [1 gallon = 4 quarts, 1 quart = 0.946 liter]

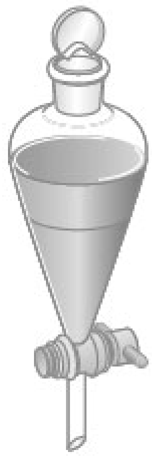
a. 4.3 L b. 4.8 L
c. 68 L d. 76 L

35. The boiling point of liquid nitrogen is 77 K. What is this temperature on the Celsius scale?

a.350°C b.171°C

c.25°C d.–196°C

36. Consider the separatory funnel shown below that contains two liquids.



Water is placed in the funnel along with one of the following liquids. The funnel is then opened and the bottom layer is drained into a beaker. For which combination would the water end up in the beaker? Density values are given in parentheses.

a. diethyl ether (0.713 g/mL)

b. mineral oil (0.845 g/ml)

c. dichloromethane (1.33 g/mL)

d. both a and b

37. At the 2008 Olympics the Jamaican runner Shelly Ann Fraser ran the 100. meter dash in world record time of 10.78 seconds. What is this speed in miles per hour?
[1 mile = 1.609 km]

a.2.08 mph b.4.81 mph

c.20.8 mph d.48.1 mph

38. Which of the following is true of the relationship between density expressed in g/mL and specific gravity?

a. They have different numerical values and different units.

b. They have the same numerical value and the same units.

c. They have the same numerical value but specific gravity is dimensionless.

d. They have the same units but different numerical values.

39. In which of the following are the lengths given in the correct order?

a. cm > mm > m > km b. cm > m > km > mm

c. km > m > cm > mm d. mm > cm > m > km

40. Mercury is the only metal which is a liquid at room temperature. The density of mercury is 13.6 g/cm^3. What is the mass, in pounds, of 1.00 quart of mercury? [1 liter = 1.057 quart; 1 pound = 453.6 grams]

a.0.0284 lb   b.28.4 lb

c.31.7 lb   d.35.3 lb

41. Which of the following statements is true about a swinging pendulum?

a. Its kinetic energy is greatest when it is vertical (at the midpoint of its swing).

b. Its potential energy is greatest when it is vertical (at the midpoint of its swing).

c. Its kinetic energy does not change as it swings.

d. Its potential energy does not change as it swings.

42. Which state of matter retains its volume but adapts its shape to that of its container?

a.solid   b.liquid

c.gas   d.none of these

43. Which of the following would be the most appropriate unit to measure the diameter of an ant's leg?

a.Gm   b.m

c.cm   d.µm

44. Given the calculation: $(6.49 \times 10^{7}) \times (7.1 \times 10^{5})$ = ?, what is the answer reported to the correct number of significant figures?

a.4.6079×10^{13} b.4.6×10^{13}

c.4.6×10^{2} d.4.6079×10^{2}

45. At what temperature do the temperatures on the Celsius and Fahrenheit scales have the same numerical value?

a.–40.   b.0

c.32   d.at no value

46. Which metric prefix is commonly abbreviated using a Greek letter?

a.mega   b.micro

c.milli   d.nano

47. In the SI system of units the basic unit of volume is the cubic meter (m^3). A volume of 1 m^3 is equal to which of the following?

a.1 L   b.10 L

c.100 L   d.1000 L

48. If a certain amount of heat is added to a 30.0 gram sample of water the temperature of the sample increases from 27.0°C to 57.0°C. If this same amount of heat is added to a 90.0 gram sample of water initially at 40.0°C what will be the final temperature of the water?

a.30.0°C b.50.0°C

c.70.0°C d.90.0°C

49. Consider the following piece of equipment found in a chemistry laboratory.

This equipment could be used to measure:

a.mass. b.volume.

c.length. d.temperature.

50. The Law of Conservation of Energy states which of the following?

a.energy cannot be converted from one form to another

b.kinetic energy is conserved

c.potential energy is conserved

d.none of the above

Answer Key

1. b

2. c

3. b

4. c

5. b

6. b

7. a

8. b

9. c

10. c

11. c

12. d

13. a

14. d

15. c

16. c

17. c

18. c

19. c

20. c

21. a

22. c

23. d

24. b

25. d

26. b

27. b

28. c

29. a

30. c

31. b

32. d

33. c

34. c

35. d

36. d

37. c

38. c

39. c

40. b

41. a

42. b

43. d

44. b

45. a

46. b

47. d

48. b

49. a

50. d