More Preliminaries

Scientific Method
Metric System
Uncertainty

Complex sig figs

- What if it uses both addition and multiplication rules?
- Round when you change rules.

Scientific method.

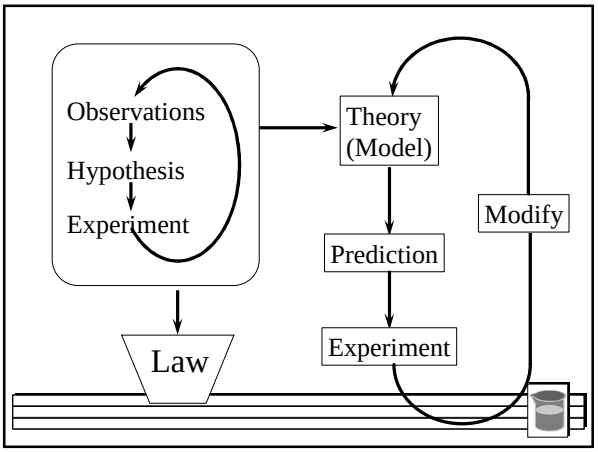
- A way of solving problems
- Observation- what is seen or measured
- Hypothesis- educated guess of why things behave the way they do. (possible explanation)
- Experiment- designed to test hypothesis
- leads to new observations,
- and the cycle goes on

Scientific method.

- After many cycles, a broad, generalizable explanation is developed for why things behave the way they do
- Theory
- Also regular patterns of how things behave the same in different systems emerges
- Law
- Laws are summaries of observations
- Often mathematical relationship

Scientific method.

- Theories have predictive value.
- The true test of a theory is if it can predict new behaviors.
- If the prediction is wrong, the theory must be changed.
- Theory- why
- Law – how
- Law – equation of how things change



Metric System

- Every measurement has two parts
- Number
- Scale (unit)
- SI system (le Systeme International) based on the metric system
- Prefix + base unit
- Prefix tells you the power of 10 to multiply by - decimal system -easy conversions

Metric System

- Base Units
- Mass - kilogram (kg)
- Length- meter (m)
- Time - second (s)
- Temperature- Kelvin (K)
- Electric current- ampere (amp, A)
- Amount of substance- mole (mol)

Prefixes

giga-	G	1,000,000,000	10^9
mega -	M	1,000,000	10^6
kilo -	k	1,000	10^3
deci-	d	0.1	10^{-1}
centi-	c	0.01	10^{-2}
milli-	m	0.001	10^{-3}
micro-	μ	0.000001	10^{-6}
nano-	n	0.000000001	10^{-9}

Deriving the Liter

- Liter is defined as the volume of 1 dm^3
- gram is the mass of 1 cm^3

Mass and Weight

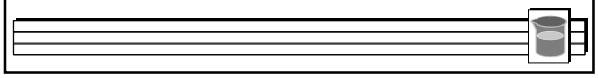
- Mass is measure of resistance to change in motion
- Weight is force of gravity.
- Sometimes used interchangeably
- Mass can't change, weight can

Uncertainty

- Basis for significant figures
- All measurements are uncertain to some degree
- Precision- how repeatable
- Accuracy- how correct - closeness to true value.
- Random error - equal chance of being high or low- addressed by averaging measurements - expected

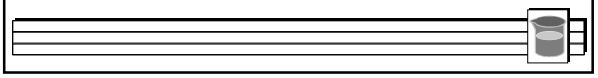
Uncertainty

- Systematic error- same direction each time
- Want to avoid this
- Bad equipment or bad technique.
- Better precision implies better accuracy
- You can have precision without accuracy
- You can't have accuracy without precision (unless you're really lucky).



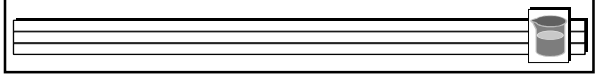
Dimensional Analysis

Using the units to solve problems



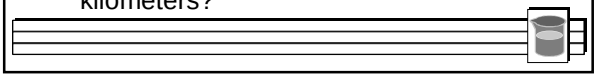
Dimensional Analysis

- Use conversion factors to change the units
- Conversion factors = 1
- 1 foot = 12 inches (equivalence statement)
- $\frac{12\text{ in}}{1\text{ ft.}} = 1 = \frac{1\text{ ft.}}{12\text{ in}}$
- 2 conversion factors
- multiply by the one that will give you the correct units in your answer.



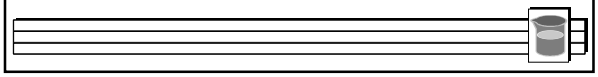
Examples

- 11 yards = 2 rod
- 40 rods = 1 furlong
- 8 furlongs = 1 mile
- The Kentucky Derby race is 1.25 miles. How long is the race in rods, furlongs, meters, and kilometers?
- A marathon race is 26 miles, 385 yards. What is this distance in rods and kilometers?



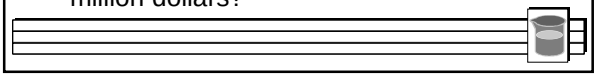
Examples

- Science fiction often uses nautical analogies to describe space travel. If the starship U.S.S. Enterprise is traveling at warp factor 1.71, what is its speed in knots?
- Warp 1.71 = 5.00 times the speed of light
- speed of light = 3.00×10^8 m/s
- 1 knot = 2000 yd/h exactly



Examples

- Because you never learned dimensional analysis, you have been working at a fast food restaurant for the past 35 years wrapping hamburgers. Each hour you wrap 184 hamburgers. You work 8 hours per day. You work 5 days a week. you get paid every 2 weeks with a salary of $840.34. How many hamburgers will you have to wrap to make your first one million dollars?



- A senior was applying to college and wondered how many applications she needed to send. Her counselor explained that with the excellent grade she received in chemistry she would probably be accepted to one school out of every three to which she applied. She immediately realized that for each application she would have to write 3 essays, and each essay would require 2 hours work. Of course writing essays is no simple matter. For each hour of serious essay writing, she would need to expend 500 calories which she could derive from her mother's apple pies. Every three times she cleaned her bedroom, her mother would made her an apple pie. How many times would she have to clean her room in order to gain acceptance to 10 colleges?

Units to a Power

- How many m^3 is 1500 cm^3?

$$1500\ cm^3 \frac{1\ m}{100\ cm} \frac{1\ m}{100\ cm} \frac{1\ m}{100\ cm}$$

$$1500\ cm^3 \left(\frac{1\ m}{100\ cm}\right)^3$$

Units to a Power

- How many cm^2 is 15 m^2?
- 36 cm^3 is how many mm^3?

Multiple units

- The speed limit is 65 mi/hr. What is this in m/s?
  - 1 mile = 1760 yds
  - 1 meter = 1.094 yds

$$65\ \frac{mi}{hr} \quad \frac{1760\ yd}{1\ mi} \quad \frac{1\ m}{1.094\ yd} \quad \frac{1\ hr}{60\ min} \quad \frac{1\ min}{60\ s}$$

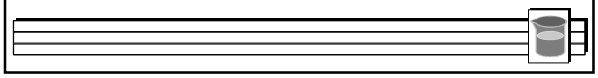
Multiple units

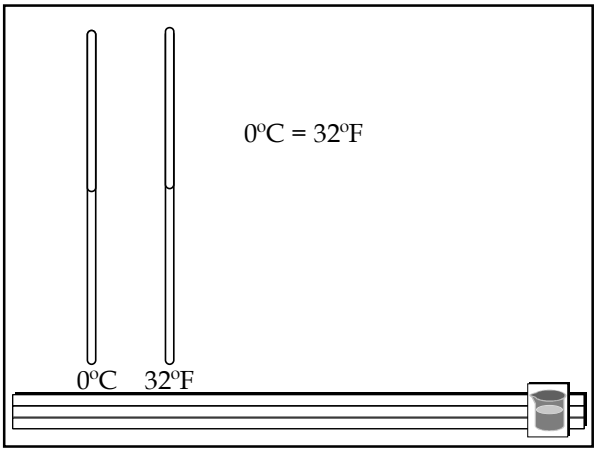
- Lead has a density of 11.4 g/cm^3. What is this in pounds per quart?
  - 454 g = 1 lb
  - 1 L = 1.094 qt

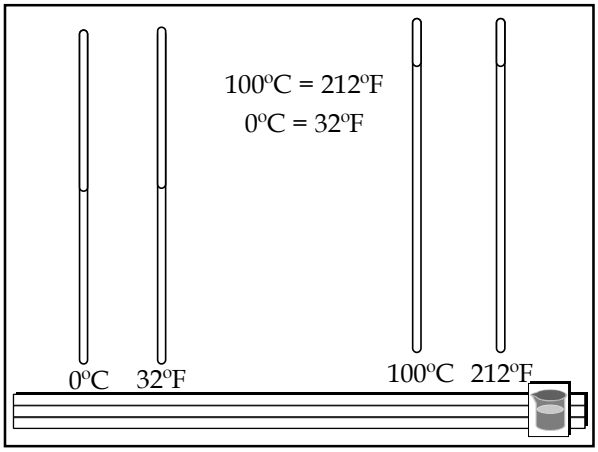
Temperature and Density

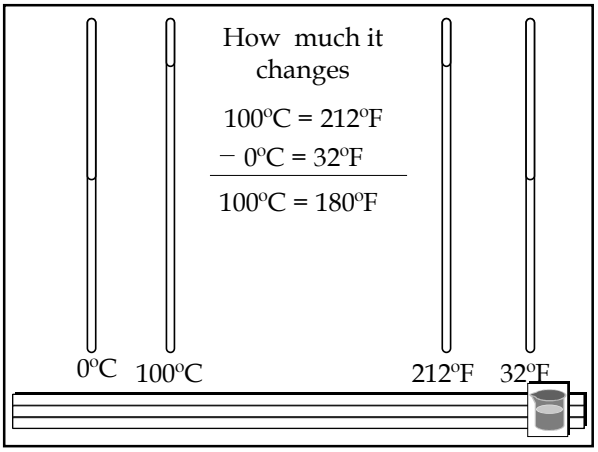
Temperature

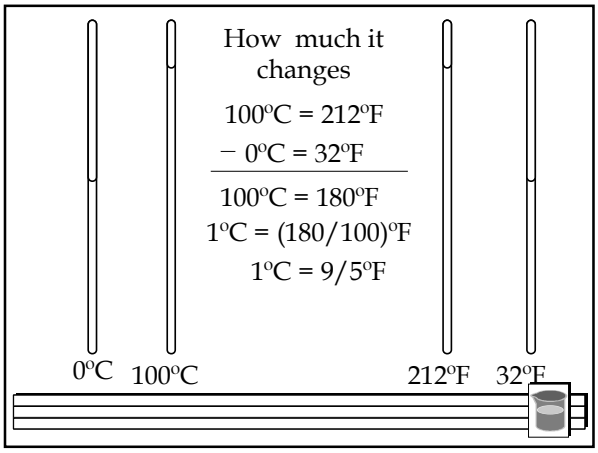
- A measure of the average kinetic energy
- Different temperature scales, all are talking about the same height of mercury.
- Derive a equation for converting ºF toºC

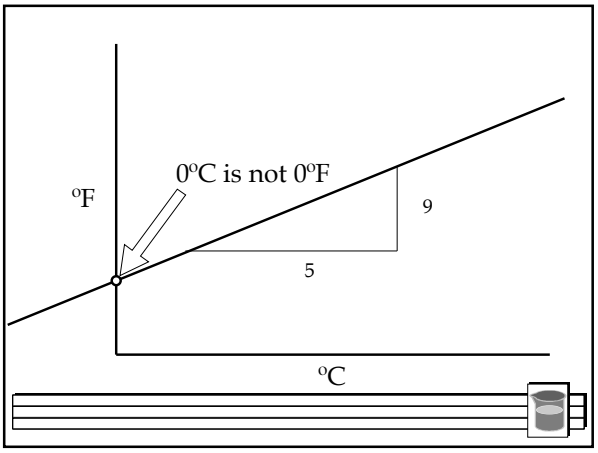


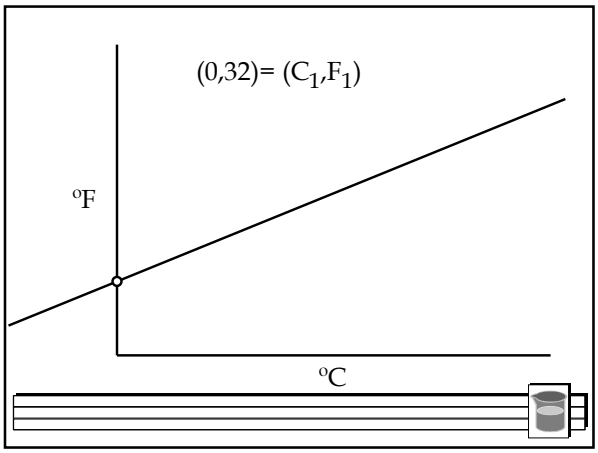


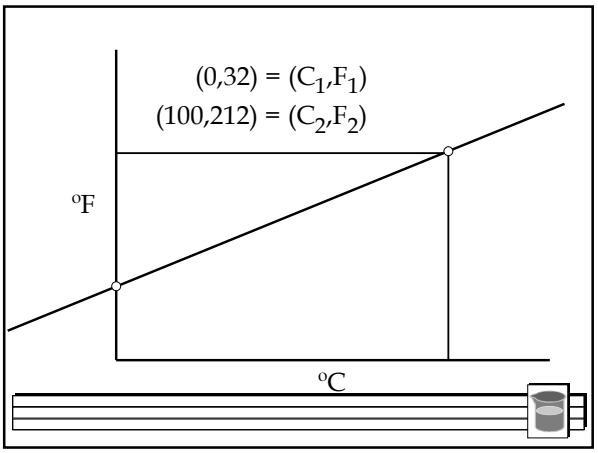












Density

- Ratio of mass to volume
- D = m/V
- Useful for identifying a compound
- Useful for predicting weight
- An intrinsic property- does depend on what the material is

Density Problem

- An empty container weighs 121.3 g. Filled with carbon tetrachloride (density 1.53 g/cm^3) the container weighs 283.2 g. What is the volume of the container?

Density Problem

- A 55.0 gal drum weighs 75.0 lbs. when empty. What will the total mass be when filled with ethanol?

  density 0.789 g/cm^3
  1 gal = 3.78 L
  1 lb = 454 g

Physical Changes

- A change that changes appearances, without changing the composition.
- Chemical changes - a change where a new form of matter is formed.
- Also called chemical reaction.
- Not phase changes
  - Ice is still water.

Mixtures

- Made up of two substances.
- Variable composition.
- Heterogeneous- mixture is not the same from place to place.
- Chocolate chip cookie, gravel, soil.
- Homogeneous- same composition throughout.
- Kool-aid, air.
- Every part keeps its properties.

Separating mixtures

- Only a physical change- no new matter
- Filtration- separate solids from liquids with a barrier
- Distillation- separate because of different boiling points
  - Heat mixture
  - Catch vapor in cooled area
- Chromatography- different substances are attracted to paper or gel, so move at different speeds

Chromatography

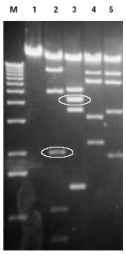


Fig.1. Genomic xhlf DNA run on a 1.2% agarose gel and digested with BamHI, EcoRI, HindIII, SalI, and XhoI. DNA bands corresponding to EcoRI 2,000 base pair fragment and HindIII 4,000 base pair fragment (circled) were excised and the DNA isolated and sequenced.

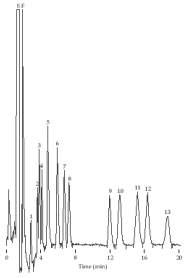


Fig 2.7 Chromatogram obtained with Electrochemical Detector

Phases

- A part of a sample with uniform composition, therefore uniform properties
- Homogeneous- 1 phase
- Heterogeneous – more than 1

Solutions

- Homogeneous mixture
- Mixed molecule by molecule
- Can occur between any state of matter.
- Solid in liquid- Kool-aid
- Liquid in liquid- antifreeze
- Gas in gas- air
- Solid in solid - brass
- Liquid in gas- water vapor

Solutions

- Like all mixtures, they keep the properties of the components.
- Can be separated by physical means
- Not easily separated- can be separated without creating anything new.

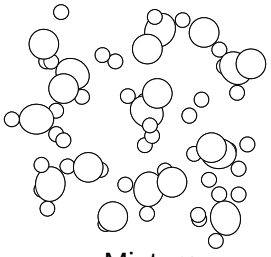
Substances

- Elements- simplest kind of matter
- Cannot be broken down into simpler
- All one kind of atom.
- Compounds are substances that can be broken down by chemical methods
- When they are broken down, the pieces have completely different properties than the compound. Salt
- Made of molecules- two or more atoms stuck together

Compound or Mixture

Compound	Mixture
One kind of piece- Molecules	More than one kind - Molecule or atoms
Making is a chemical change	Making is a physical change
Only one kind	Variable composition

Which is it?



Compound Mixture