Lecture 1: Getting Started

(Zumdahl 6th Edition)

Chapter 1-2.4   Appendix One and Two

Outline:

- Review Syllabus
- **The scientific Method (how you know what you know)**
- **The importance of solving problems**
- **Approaching Problem Solving (Appendix 1)**
- **Units and Conversion Factors (Appendix 2)**

Summarize Syllabus

- Where to find it
  - https://catalyst.uw.edu/workspace/chemfa11/...
  - Text (paper back is probably preferred)
- There is a lab part (4 labs this q.), and prelab.
  - Discussed more fully Friday. (15%)
- There is a discussion/review part with TA and guided study material. (Thursday, 10%) Go there this Thurs – work on measurement, scientific notation and significant figures.
- ALEKS – On line learning environment (Monday, 10%)
- Three exams (on Monday) -- MC -- 65%
  - 2.6 is mean grade (based on about 72%)
  - Sources of exam questions (test banks, problems in book, ALEKS, old exams, worksheet problems)

Resources

- Review Syllabus, Know your times for labs and exams.
- Do ALEKS every day (Due Friday)
- Do Problems in the chapter and at the end. (Do **not** peek; try them or ask first.)
- Thursday practice worksheets.
- Catalyst Discussion Board
- 330 Bagley, TAs and others often there
- CLUE center in Mary Gates Hall.

- Don't get sick. What to do:
  - Purell, get Tamiflu if you can, get vaccine
  - Stay home if sick.

The Center for Learning and Undergraduate Enrichment

CLUE

Drop in Chemistry Tutoring

- Mary Gates Hall Thurs-Sun 7pm-midnight
- Poplar Hall: Tues and Thurs 7-10pm
- McCarty Hall: Tues and Thurs 7-10pm

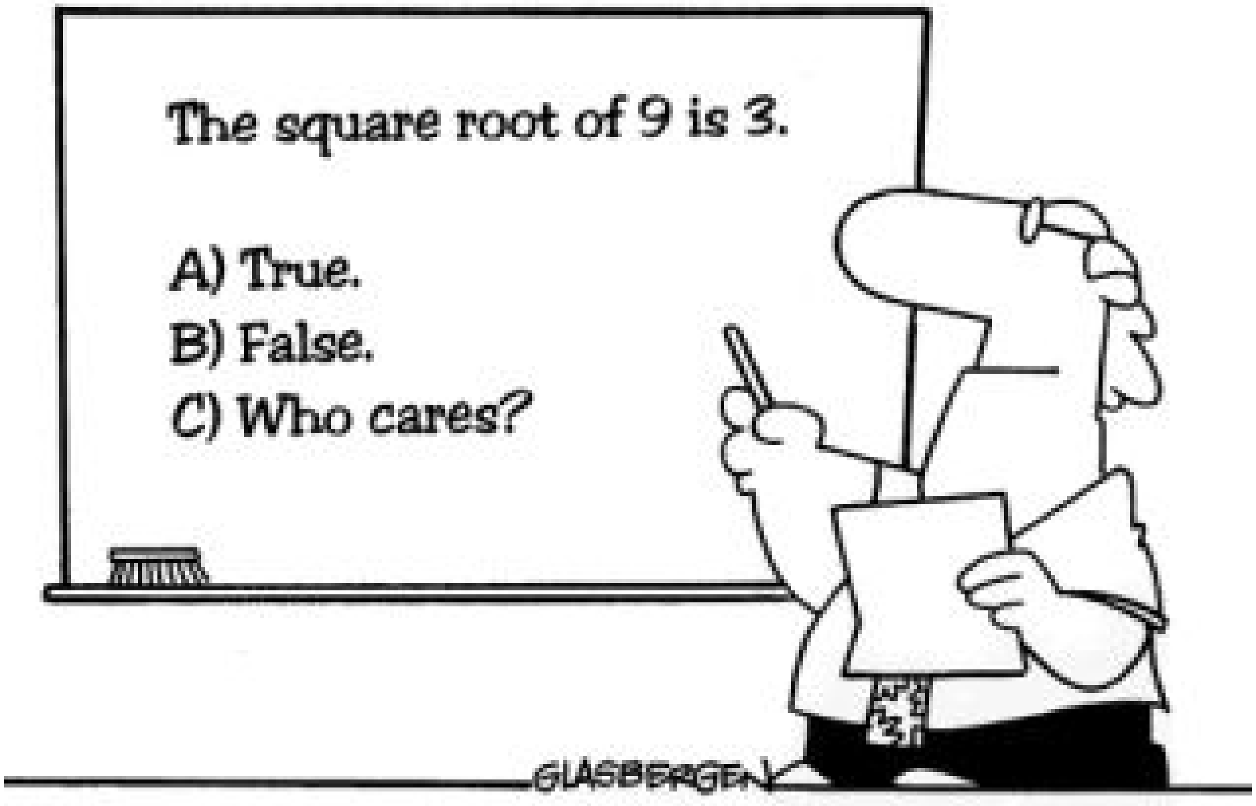
For more information:

depts.washington.edu/clue/index.php

Knowledge Objectives

- First 8 chapters of Zumdahl.
- Stoichiometry
  - Follow Chemical Reactions from start to end or to equilibrium point.
  - It is about change with constraints (a bank account) Mass is conserved, matter is conserved charge is conserved, and all elements are conserved. Sometimes Volume is conserved.
  - Applications: Burning, Oxidation/Reduction, Batteries, Atmophere reactions, complex formation, salt formation (and ppt), reactions of acids or bases and salts in water, acid/base reactions, buffers and titration.

You can't solve chemistry problems without math.



Many students actually look forward to Mr. Atwadder's math tests.

Homework is at the heart of learning any science

Solving problems is the only way to know whether or not you know the material. In addition to ALEKS look over problems in the back, work with others, practice the process of solving problems with paper and pencil. This approach prepares for exams.

Work *individually* on your homework! (But do not "spin your wheels") Work in groups to teach others.

" Chemistry is not a spectator sport. You must become involved. And that means that you must do homework!" ---- Linus Pauling (1967)

Conversion Factors: A summary (Apx 2.2)

- English Units and MKS (comparison)

M
  - A meter is a yard (and 10% more)

K
  - A Kilogram (or kilo on the street) is 2 pounds (and 10% more).
  - A liter is a derived quantity,
    - Volume is height by width by depth (distance cubed)
  - A liter is a quart (and 5% more)

S
  - A second is a second

$$1meter = 39.37inches \quad \Rightarrow \quad 1 = \frac{1}{39.37}\left(\frac{meters}{inches}\right)$$

$$x = 4.2inches = 4.2 \bullet \frac{1}{39.37}\left(\frac{meters}{inches}\right)inches = \frac{4.2}{39.37}\left(inches \cdot \frac{meters}{inches}\right) = 0.107meters$$

Appendix two: SI system of units

Fundamental Units in the SI (MKS) system

Table A2.1

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

Also see back Flyleaf of Text for Units and conversion factors.

All Measured Quantities Consist of a Number and a Unit

Conversion factors have units but no dimensions. For example 1 inch = 2.54 centimeters or

C= 2.54 cm/inch = 1 (no units)

Notice C is a conversion factor that has units of centimeters per inch. So if you have a book that is 12 inches in length, the length of the book, h is:

h = 12 inches = 12 inches*C= 12*2.54 in*cm/in

h = 12*2.54=30 cm. Notice the inches unit cancels and h has dimensions of length at the end of the conversion.

Definitions - Mass & Weight

Mass - The quantity of matter an object contains

kilogram - (kg) - the SI base unit of mass, is a platinum - iridium cylinder kept in Paris as a standard!

Weight - depends upon an object's mass and the strength of the gravitational field pulling on it, i.e.

$$weight = force = m \cdot g \quad g = 9.8 \, {}^{meters}\!/_{\sec^2}$$

Basic Facts about Density

- Water has a density ~ 1 gram/cc
- Air has a density ~ 1 gram/liter
- Therefore water is ~1000 times more dense than air.
- What does water weigh (density) in English Units?

$$d = 1\left({}^{g}\!/\!{}_{cc} \right) \cdot 10^{-3} \left({}^{kg}\!/\!{}_{g} \right) \cdot 10^{3} \left({}^{cc}\!/\!{}_{\ell} \right)$$

$$= 1\,{}^{kg}\!/\!{}_{\ell} \cdot \left(\frac{2.20\,{}^{lb}\!/\!{}_{kg}}{1.06\,{}^{qt}\!/\!{}_{\ell}} \right) \cdot = 2.08\,{}^{lb}\!/\!{}_{qt}$$

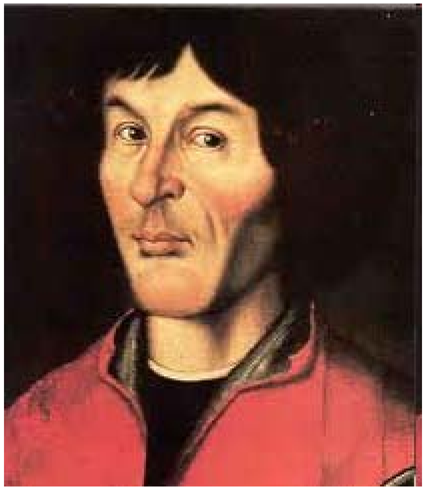
- "A pint's a pound, the world around" --

Anonymous

The Approach of the Scientific Method

- Understand how the world around us works.
- The real point is that someone can set out an experiment that others can review and reproduce.
- The explanation is a collective process among many people who used experiments to rule out incorrect ideas.
- The Steps:
  - Gather data (information) by careful observation of the phenomenon being studied.
  - Based of that information, form a preliminary hypothesis (i.e. a guess).
  - See if the hypothesis predicts the outcome of new experiments. (i.e. Test the Hypothesis)

Roots of Atomic Theory



- Nicolaus Copernicus
- A man of faith, but he let the data guide his conclusions: It was easier to describe the motion of planets if you put the sun at the center.
- Compare this to today's theories:
  - Evolution, Global Warming
  - Germ theory of disease
  - Cancer and environmental effects

Roots of Atomic Theory

- Greek Version of Theory of Matter
- Dalton: Understood the essence of molecular structure.
  - Mass is always conserved in a chemical reaction
  - Elements combined in simple numbers to make (simple) substances (i.e. molecules)
- Had a rough idea: Elements (i.e. Atoms) combined by type (weight was not important)
- However the only thing he (we) can do is measure the weight of stuff.

Cannizzaro Cuts the Gordian Knot

- Cannizzaro trusted
  - Dalton's Atomic Theory
  - Avogadro's Hypothesis
- Atomic theory requires
  - Molecular formulae
  - Atomic weights
- If we know the atomic weights we can determine the molecular formulae
- If we know the molecular formulae we can determine the atomic weights .
- Developed a system of atomic masses (i.e. weights) to fit a larger number of substances (i.e. molecules).

A Puzzle (from Gay-Lussac and Cannizzaro)

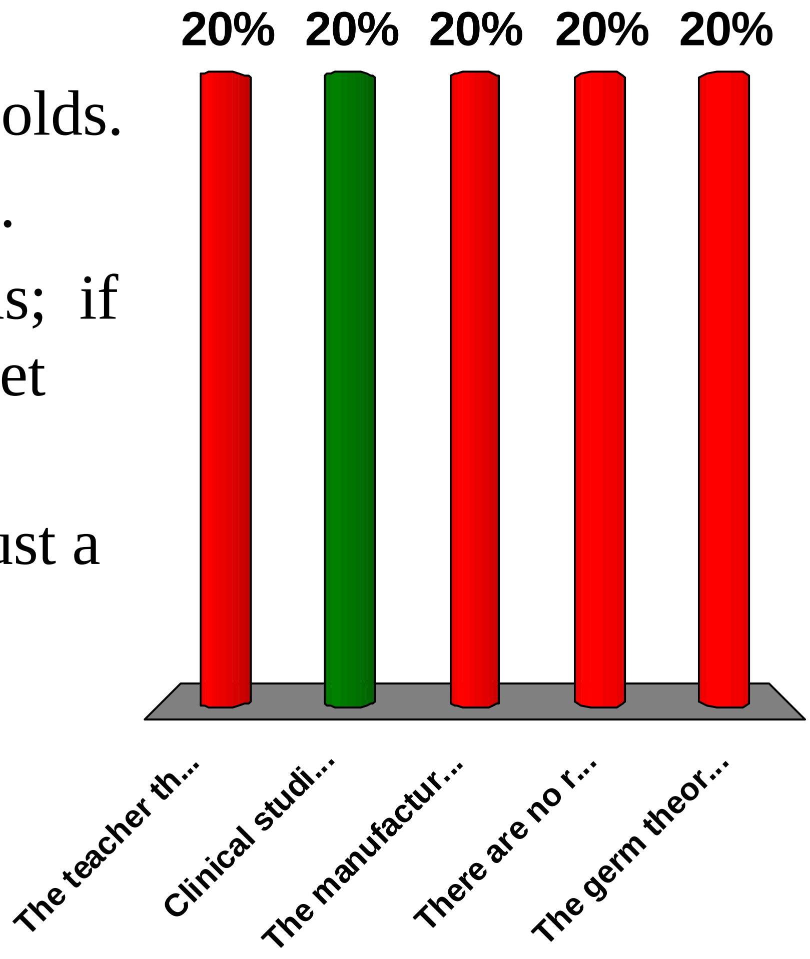
- 2 Vol Hydrogen, and 1 Vol Oxygen give 2 Vol water vapor.
- Rule out the possibility that H and O are monoatomc.
- What might the chemical formula be for water?
- Water is 1/9 Hydrogen (by mass).
- What are the relative weights of Oxygen and Hydrogen?

Extra Items Beyond Here

- Extra examples and problems that we will not have time to cover in lecture.
- You might want to explore some of these things as an aid to doing problems

Valid Reasons to use Purell

1. The teacher thinks it's a good idea.
2. Clinical studies have shown it significantly reduces catching colds.
3. The manufacturer says it works.
4. There are no really good reasons; if you are going to get sick, you get sick.
5. The germ theory of disease is just a theory and may not be correct.



Derived SI Units

Quantity	Definition of Quantity	SI unit
Area	Length squared	m^2
Volume	Length cubed	m^3
Density	Mass per unit volume	kg/m^3
Speed	Distance traveled per unit time	m/s
Acceleration	Speed changed per unit time	m/s^2
Force	Mass times acceleration of object	$kg\ m/s^2$ (= newton, N)
Pressure	Force per unit area	$kg/(m\ s^2)$ (= pascal, Pa)
Energy	Force times distance traveled	$kg\ m^2/s^2$ (= joule, J)

Example calculations using units

Length : A car is 12 feet long, not “12 long”.
A person is 6 feet tall, not “6 tall”.

Area : A carpet measuring 3.0 feet(ft) by 4.0 ft has an area of:

x=Area = (3.0 ft)x(4.0 ft) = (3.0 x 4.0)(ft x ft) = 12 ft^2

Speed and Distance : A car traveling 351 miles(mi) in 7.0 hours(hr) has a speed of:

x=Speed has U(distance/time) =351 mi / 7.0 hr
= (351/7.0) x (mi/hr) = 50. mi/hr

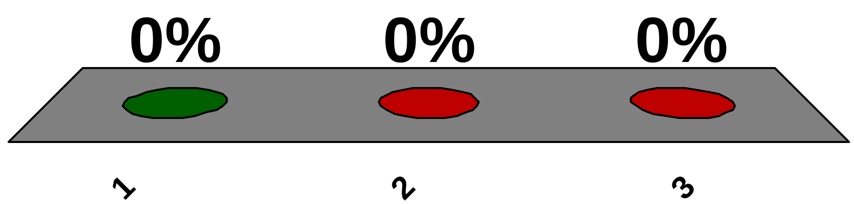
Which of the following has units of density?

(1) $d = 0.49\times10^{3}\ \frac{\text{mg}}{\text{m}^{3}}$

(2) $d = 1.49\times10^{3}\left(\frac{\text{gm}}{\text{m}}\right)$

(3) $d = 1.49\times10^{3}\ \frac{\text{mg}}{cm}$

1. 1
2. 2
3. 3



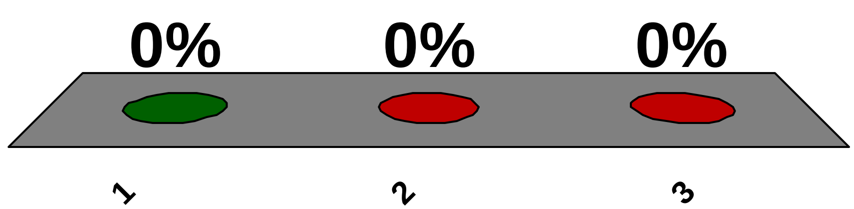
Which of the following has units of density?

$$(1)\quad d = \frac{1.49\times10^{3}\text{mg}}{20.9\text{mm}\times11.1\text{mm}\times11.9\text{mm}}\times\frac{1\text{g}}{1000\text{ mg}}\times\left(\frac{10\text{mm}}{1\text{cm}}\right)$$

$$(2)\quad d = \frac{1.49\times10^{3}}{20.9\text{mm}\times11.1\text{mm}\times11.9\text{mm}}\times\frac{1\text{g}}{1000\text{ mg}}\times\left(\frac{10\text{mm}}{1\text{cm}}\right)$$

$$(3)\quad d = \frac{1.49\times10^{3}\text{mg}}{20.9\text{mm}\times11.1\text{mm}}\times\frac{1\text{g}}{1000\text{ mg}}\times\left(\frac{10\text{mm}}{1\text{cm}}\right)$$

1. 1
2. 2
3. 3



Calculations Involving Density (1)

Calculate the mass in grams of 1.00 ft^3 of lead (density = 11.3 g/ cm^3)?

Step 1: Make sure you understand the task:

Calculate the mass of a given volume of lead.

Step 2: Make sure you understand the given information:

The volume is 1.00 ft^3 and the density is 11.3 g/cm^3.

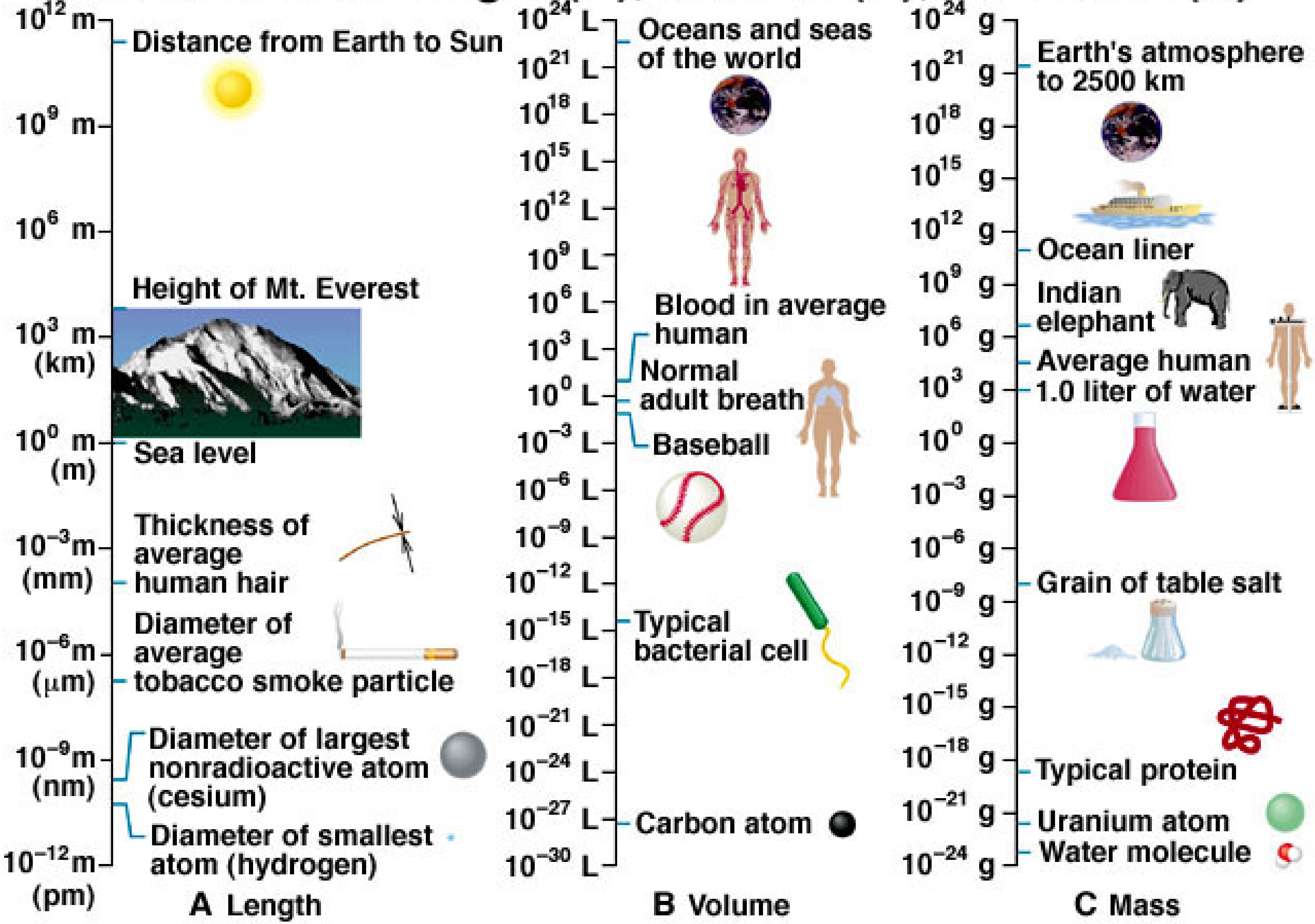
Step 3: Develop a strategy:

Density = mass/volume, so mass = (density) x (volume).
Use units to help you formulate the problem.

Common SI-English Equivalent Quantities

Quantity	SI	SI Equivalents	English Equivalents	English to SI Equivalent
Length	1 kilometer (km)	1000 (10^3) meters	0.6214 mile (mi)	1 mile = 1.609 km
	1 meter (m)	100 (10^2) centimeters	1.094 yards (yd)	1 yard = 0.9144 m
		1000 millimeters (mm)	39.37 inches (in)	1 foot (ft) = 0.3048 m
	1 centimeter (cm)	0.01 (10^{-2}) meter	0.3937 inch	1 inch = 2.54 cm (exactly)
Volume	1 cubic meter (m^3)	1,000,000 (10^6) cubic centimeters	35.31 cubic feet (ft^3)	1 cubic foot = 0.02832 m^3
	1 cubic decimeter (dm^3)	1000 cubic centimeters	0.2642 gallon (gal)	1 gallon = 3.785 dm^3
			1.057 quarts (qt)	1 quart = 0.9464 dm^3
	1 cubic centimeter (cm^3)	0.001 dm^3	0.03381 fluid ounce	1 quart = 946.4 cm^3 1 fluid ounce = 29.57 cm^3
Mass	1 kilogram (kg)	1000 grams	2.205 pounds (lb)	1 pound = 0.4536 kg
	1 gram (g)	1000 milligrams (mg)	0.03527 ounce (oz)	1 ounce = 28.35 g

Quantities of Length (A), Volume (B), and Mass (C)



Hierarchy of Models

Hypothesis – a possible explanation of an observation or set of observations.

Masses attract one another.

Theory – An overall explanation of some natural phenomenon. (Makes predictions and can be tested)

Two masses attract each other with a force proportional to the product of their masses and inversely proportional to the distance between them.

Law – a summary of observed behaviors.

A mass falls when I drop it.

How Hypotheses Evolve

On the basis of the experimental tests: the hypothesis may be

(a) Accepted as scientific theory.

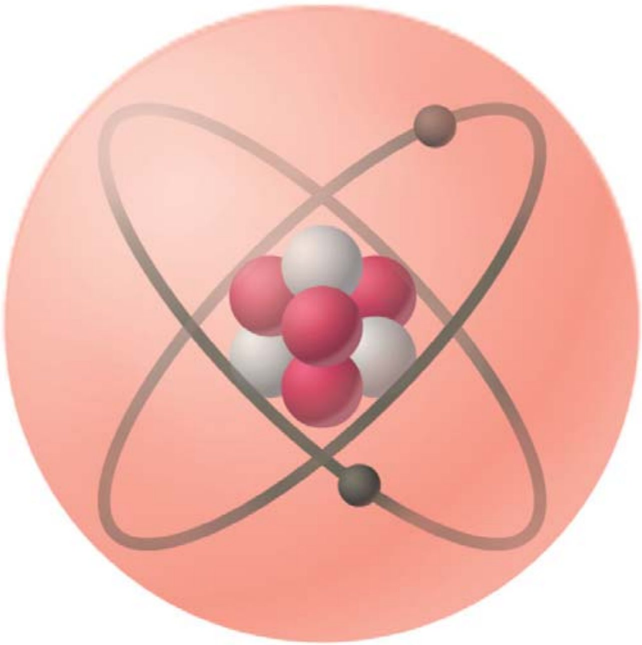
(b) Modified so that all results are adequately explained.

(c) Discarded.

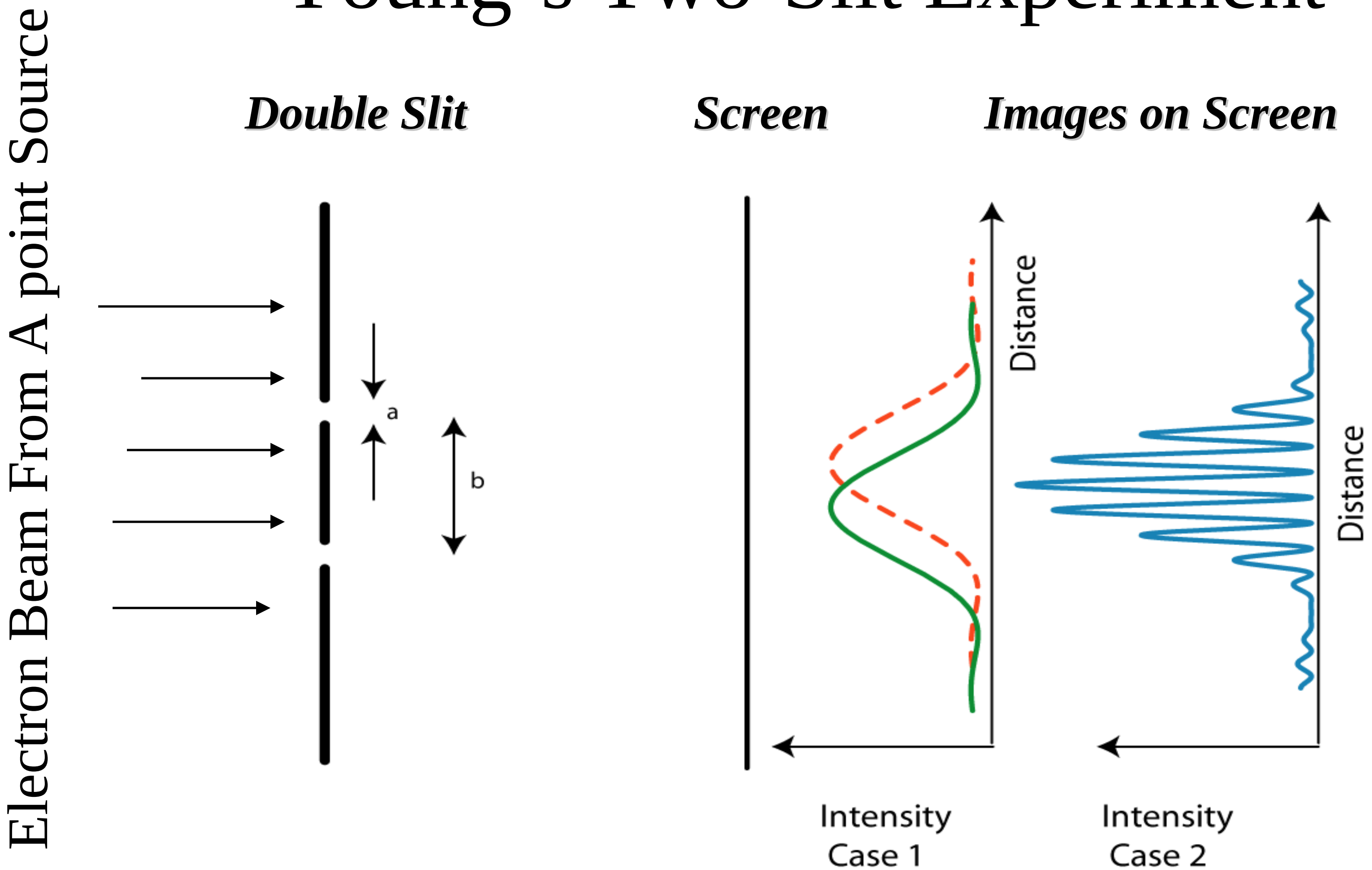
Theories evolve in time to integrate new knowledge

Classical Mechanics at the end of 19^{th} century

Light is a wave, and an electron is a particle



Young’s Two-Slit Experiment



Shoot a beam of electrons (one at a time) through the double slit

Case 1: Only one slit open at a time

Case 2: Both slits open.

Chemistry is Pure Poetry

Much of the time it sounds like Lewis Carroll:

Twas brillig, and the slithy toves
Did gyre and gimble in the wabe:
All mimsy were the borogoves,
And the mome raths outgrabe.

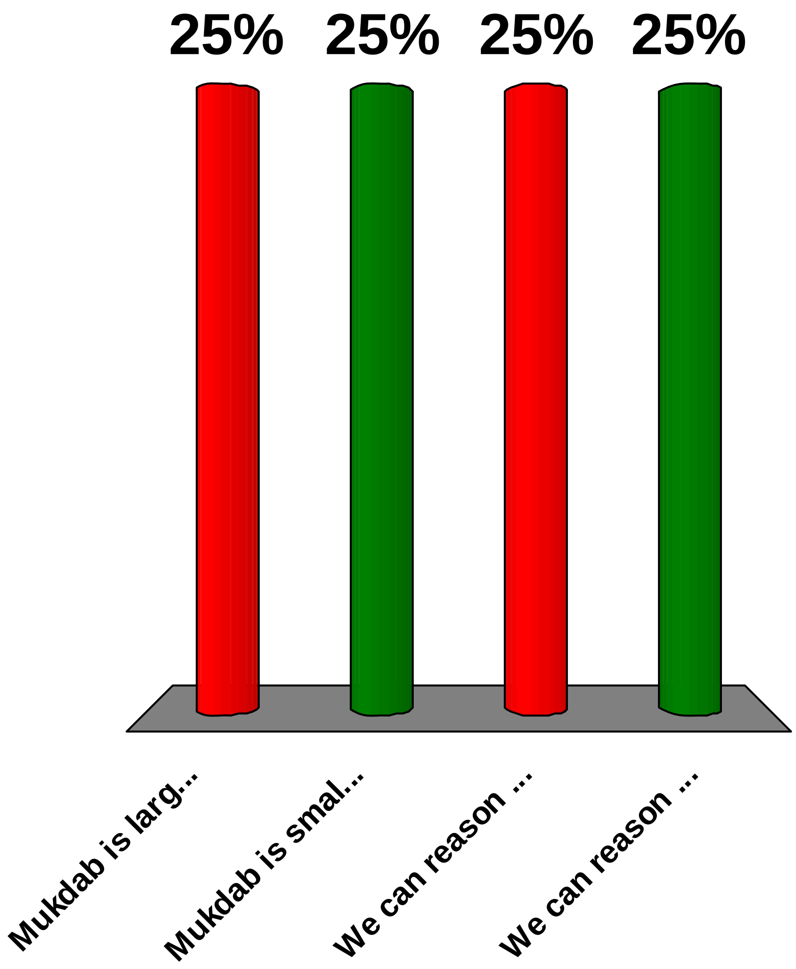
So: Sometimes just following the rules of units can help you out of this mess.

Eg: 2.48 mukdabs is equivalent to 0.785 jorbels. If I have .065 jorbels how many mukdabs do I have? Is a jorbel larger or smaller than a nukdab?

Which is larger: a mukdab or a jorbel?

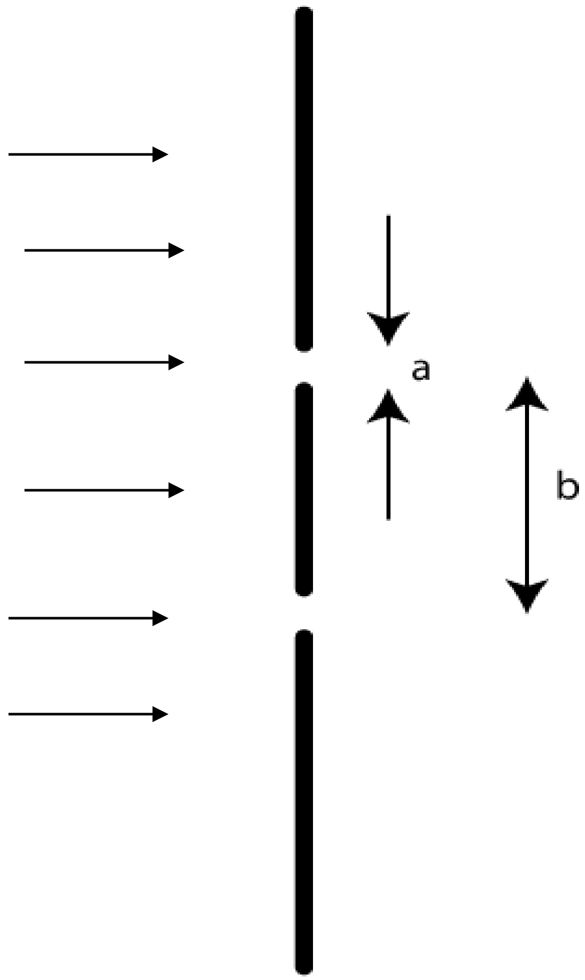
2.48 mukdabs is equivalent to 0.785 jorbels

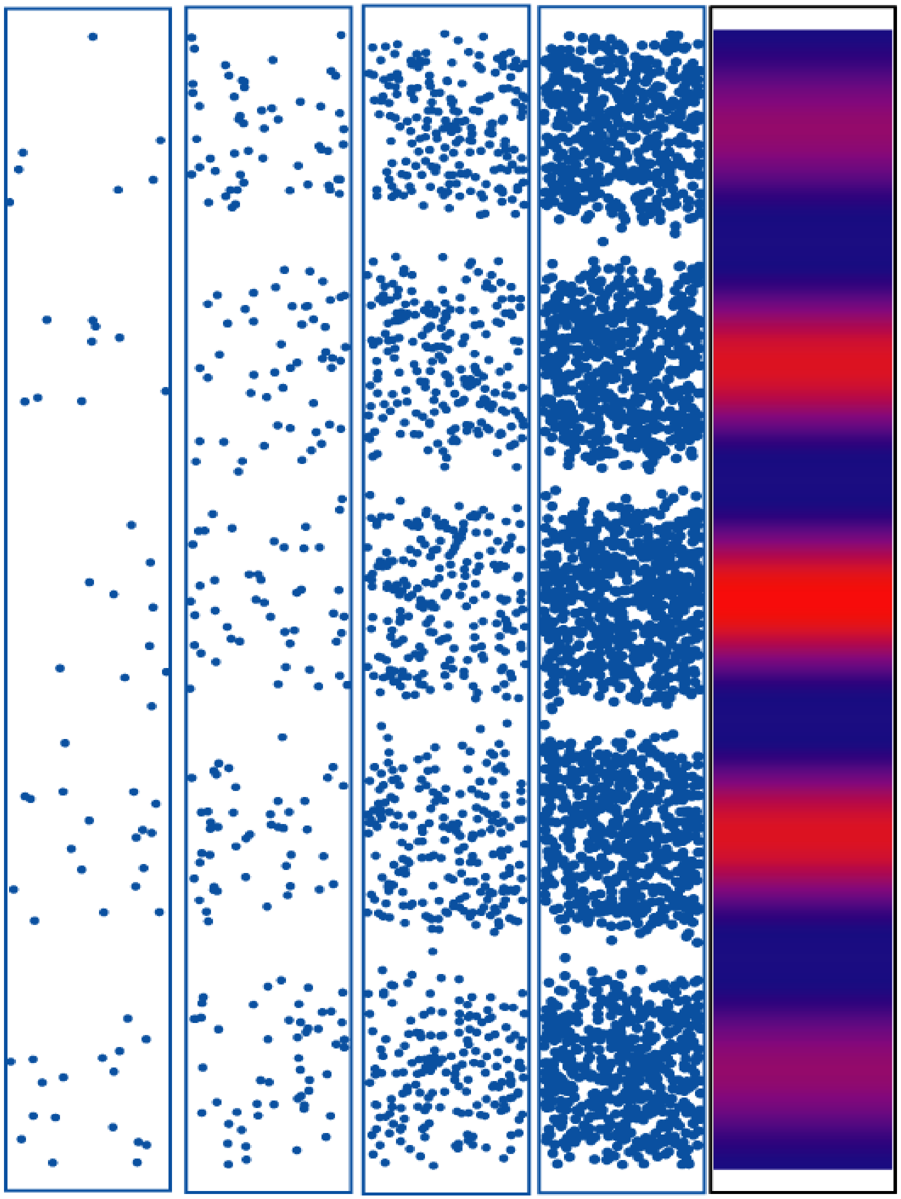
1. Mukdab is larger because 2.48 > 0.785
2. Mukdab is smaller because 2.48 > 0.785
3. We can reason from quarts and cups to show Mukdabs are larger
4. We can reason from quarts and cups to show Mukdabs are smaller



Building up an interference pattern

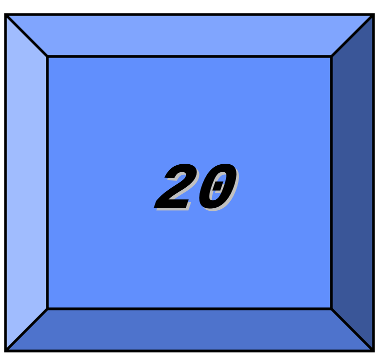
Shoot one electron at a time

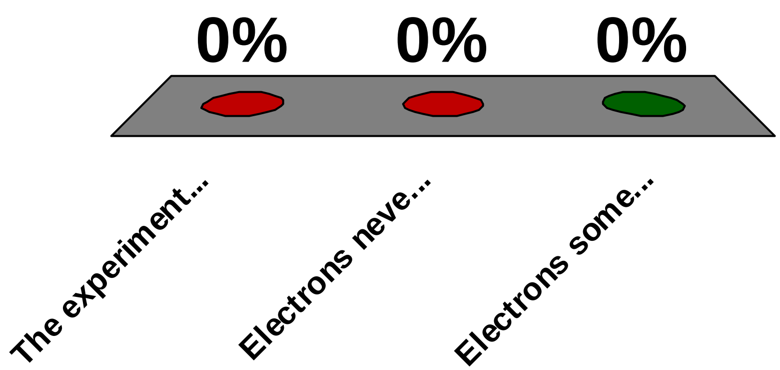




You can conclude from the Two-Slit Experiment that

1. The experiment is flawed
2. Electrons never act like particles
3. Electrons sometimes act like waves





Is quantum mechanics the "final theory"?

• Quantum mechanics and special relativity are incompatible.

• Is there a general unified theory (GUT) which contains both?

• Leading candidate is string theory in which tiny vibrating strings of energy determine what mass and energy an entity has. *Theory predicts that space-time has 10 dimensions.*

Mathematics is the Life of the Gods.

Friedrich von Hardenberg 1772-1801

Step 4: Set up the problem:

$$m = \text{mass} = \text{density} \times \text{volume}$$

$$m = \text{mass} = 11.3\frac{\text{g}}{\text{cm}^3} \times 1.00\text{ft}^3 \times \left(\frac{12\text{ in}}{1\text{ft}}\right)^3 \left(\frac{2.54\text{ cm}}{1\text{in}}\right)^3$$

$$= 11.3\frac{\text{g}}{\text{cm}^3} \times 1.00\text{ft}^3 \times \frac{(12 \times 2.54)^3\text{ cm}^3}{1\text{ft}^3}$$

Step 5: Make sure that your formula gives you the correct units.

$$\text{mass} = 11.3\frac{\text{g}}{\cancel{\text{cm}}^3} \times 1.00\cancel{\text{ft}}^3 \times \frac{(12 \times 2.54)^3\cancel{\text{cm}}^3}{1\cancel{\text{ft}}^3}$$

Step 6: Perform the Calculation. Cancel units and get the sig figs right.

$$\text{mass} = 11.3\frac{\text{g}}{\text{cm}^3}\times 1.00\,\text{ft}^3\times\frac{(12\times 2.54)^3\ \text{cm}^3}{1\,\text{ft}^3} = 3.20\times 10^5\,\text{g}$$

$$= 320\,\text{kg}$$

Step 7: Check the result

A cube of lead one foot on a side is really heavy.

3.20×10^5 g = 320. kg ~ 700 lb, which sounds reasonable. The units of the calculated answer are correct.

Water is very "heavy" (i.e. dense) and lead is over 10 times denser.

How to Solve Chemistry Problems

Problem is given → ***???*** → ***Calculate answer***

(1) Make sure you understand the task:

What are you expected to calculate? Does the problem asks for the answer in a particular form (i.e. exponential notation, units)

(2) Make sure you understand the given information:

Read it carefully and note the units. After all, you are learning a language and there is a lot of jargon; be sure you know the terms being used.

Problem Solving (Cont'd)

(3) Develop a strategy:

What formulas do you need? Do the units need to be converted? Often the units guide which quantities need to be multiplied etc.

(4) Set up the problem:

Write down formulas linking what is given to what is to be calculated. Place all numerical factors and their units into the expression (formula) to be evaluated.

(5) Make sure that your formula gives you the correct units.

Problems (cont.)

(6) Perform the Calculation. Get the sig figs right.

(7) Check the result:

- Is your answer reasonable? (i.e. Redo the calculation to one significant figure for each quantity; are you “close/exponent within one unit?)
- Do the units in the conversion factors cancel properly to give the expected units for the answer?