Slide 1

Chemistry & The Scientific Method

The Foundations of Chemistry

Slide 2

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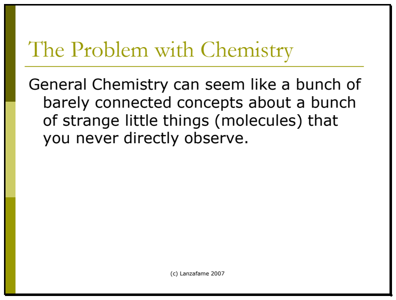
Slide 3

Why Chemistry?

Slide 4



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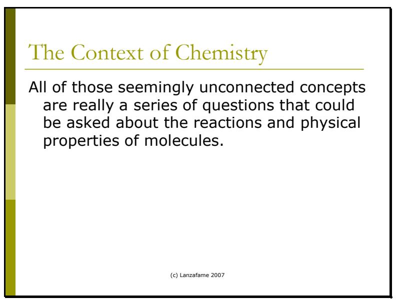

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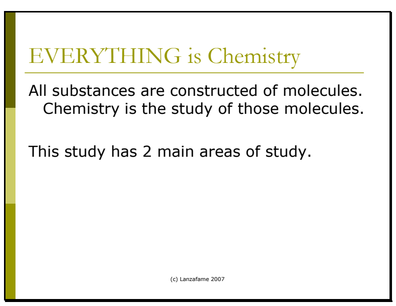

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The Physical of Chemistry

"What are their physical properties?"

1. State of matter (solid, liquid, gas)
2. Boiling point
3. Freezing point
4. Solubility in other liquids
5. Malleability
6. Electrical Conductivity
7. Heat Conduction
8. Tensile Strength

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The Chemical of Chemistry

What is the reactivity of the molecules?

1. Will they react to form new substances with A, B, or C?
2. How fast will that reaction occur?
3. Are the likely products more stable than the reactants?
4. What is the yield of the reaction? What limits the yield of the reactions?
5. Does the reaction create energy or require energy?
6. Does the reaction use electrons or generate electrons?
7. What is the structure of the new materials?
8. Are any byproducts generated by the reaction?

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The Difference?

Chemical properties (& changes) involve changes in COMPOSITION.

Physical properties (& changes) involve a constant composition.

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Example:

Boiling water

physical

It's water when you start, it's water when you end

Cracking an egg

physical

It's an egg when you start it's a (broken) egg when you finish

Boiling an egg

chemical

A bit tricky – the protein in the egg is modified by the heat which is why it changes consistency. It's a new molecule!

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Water boiling – physical change

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Slide 12

Rust

Chemical change

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Why they make you come here

The world is made up of molecules.

If you want to build a bridge, what properties must it have? What properties must its parts have?

Life is about motion and change. What causes the changes? What limits the changes? What could we do to improve the situation?

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Questions are more important than answers

Answers are fleeting and specific.

Questions can be asked over and over again.

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Chemistry is Questions

As we go through the course, try not to think of all the topics as isolated concepts.

All of our concepts are questions about molecules and their reactions or interactions.

The questions are central to every human pursuit as well as the very existence of life.

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Chemistry is about Every Thing

Chemistry is the most practical of sciences. Chemistry is rooted in the investigation of materials (real things) and their properties. As a result, other sciences rely on Chemistry for information about the "things" they study.

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Chemistry is about Measurement

An experiment requires measurement.

Measurement comes in two types:

1. Qualitative – Did you make the right stuff? Aspirin isn't insulin.
2. Quantitative – How much of something do I have (mass)? How big is it (volume)? Etc.

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We can't escape the numbers…

…except our numbers aren't really numbers!

[Are you intrigued? ☺]

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Numbers, Numbers, & More Numbers

Making sense of all the numbers

Slide 20

UNITS! UNITS! UNITS!

- Joe's 1st rule of Physical Sciences - watch the units.
- The ability to convert units is fundamental, and a useful way to solve many simple problems.
- Units also provide the context for numbers.

Slide 21

11

- Good number at the craps table.
- Bad number for an IQ.
- Okay number for a shoe size.

They are all "elevens" but they are each very different things.

Slide 22

UNITS! UNITS! UNITS!

Numbers have no meaning without UNITS! UNITS! UNITS!

The unit provides the context to the number.

A number is just a number, but a number with an appropriate unit is a datum (singular of data) - a piece of information.

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Data

11 pounds

11 dollars

11 points

These are better than just "elevens", these are data, the 11 has some context – but it could have more!

Slide 24

Data

11 pounds of raisins vs. 11 pound baby vs. 11 pounds of sand

Our units are now even more specific, providing even greater context to the number, allowing better analysis of the meaning of the number.

Slide 25

Chemical Units

- SI units - Systems Internationale - these are the standard units of the physical sciences (sometimes called the metric system).
- Units are chosen to represent measurable physical properties.
- Two types of units: "Pure" and "Derived".

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Pure Units

Represent indivisible physical quantities:

Mass – expressed in "kilograms" (kg)
Length – expressed in "meters" (m)
Time – expressed in "seconds" (s)
Charge – expressed in "Coulombs" (C)

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Derived Units

Derived units are combinations of pure units that represent combinations of properties:

Speed – meters/second (m/s) – a combination of distance and time

Volume – m^3 – combination of the length of each of 3 dimensions

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SI units

The official standard units are all metric units. The nice thing about the standard system is that the units are all self-consistent: when you perform a calculation, if you use the standard unit for all of the variables, you will get a standard unit for the answer without having to expressly determine the cancellation of the units.

Slide 29

It's all about the DATA folks!

The goal in any experimental science is to use measurement and observation as arguments in support of a thesis.

Data is NOT an end unto itself.

Data is part of a narrative. To be a good scientist, you need to learn to use data to craft an argument.

Slide 30

"Data" has a lot of subtlety

"four"
"4"
"4.0"
"4.00"
"4.00 pounds"
"4.00 pounds of carbon"
"4.00 pounds of carbon in the brain of Tyrannosaurus"

In our everyday speak, we use these interchangeably. But they aren't!

Slide 31

The UNITS! UNITS! UNITS! mean everything

"4.00"
"4.00 pounds"
"4.00 pounds of carbon"
"4.00 pounds of carbon in the brain of Tyrannosaurus"
"4.00 pounds of carbon in the brain of Teddy the Tyrannosaur whom I bred in my basement"

These are not the same thing. "4.00" could be anything: 4 dollars in my pockets, 4 toes on my left foot, 4 ex-wives…
Specificity is important – it avoids ambiguity!

Slide 32

"Data" has a lot of subtlety

"four pounds of carbon in the brain of Tyrannosaurus"
"4 pounds of carbon in the brain of Tyrannosaurus"
"4.0 pounds of carbon in the brain of Tyrannosaurus "
"4.00 pounds of carbon in the brain of Tyrannosaurus "

Beyond the UNITS! UNITS! UNITS!, the numbers themselves include information.

Slide 33

4 is not 4.0 is not 4.00 is not 4.0000

A mathematician wouldn't make a distinction.
Your grandma wouldn't make a distinction – unless she's a scientist.
A scientist makes a SIGNIFICANT distinction.

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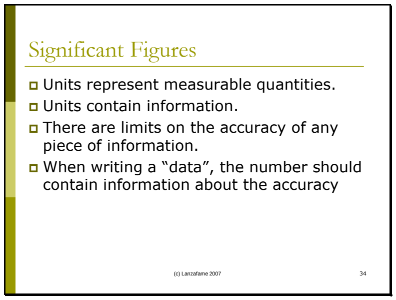

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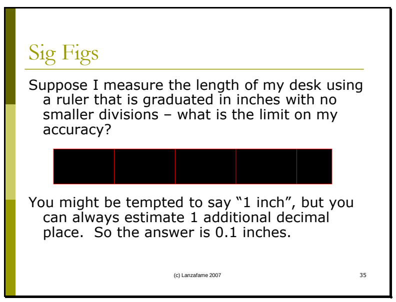

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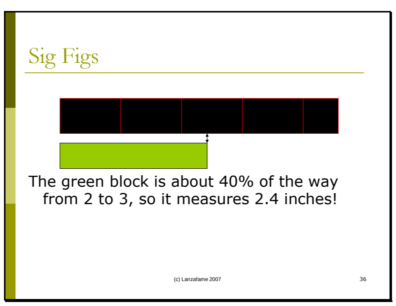

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Accuracy

So, the green block is 2.4 inches long. This is 2 "significant digits" – each of them is accurately known.

Another way of writing this is that the green block is 2.4 +/-0.05 inches long meaning that I know the block is not 2.3 in and not 2.5 in, but it could be 2.35 or 2.45 inches (both would be rounded to 2.4 inches).

Slide 38

Sig Figs

2.4 inches must always be written as 2.4 inches if it is data.

2.40 inches = 2.400 inches = 2.4 inches BUT NOT FOR DATA!

The number of digits written represent the number of digits measured and KNOWN!

Slide 39

Ambiguity

Suppose I told you I weigh 200 pounds. How many sig figs is that?

It is ambiguous – we need the zeroes to mark positions relative to the decimal place. Even if that measurement is 200 +/- 50 pounds, I can't leave the zeroes out!

Slide 40

Scientific Notation

To avoid this ambiguity, numbers are usually written in scientific notation.

Scientific notation writes every number as #.#### multiplied by some space marker.

For example 2.0 x 10^2 pounds would represent my weight to TWO sig figs.

The $10^{\#}$ markes the position, so I don't need any extra zeroes lying around.

200 2.00

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Examples of Scientific Notation

0.00038340 g = 3.8340 x 10^{-4} g

- trailing zeroes after decimal are always significant. Leading zeroes are never significant

200 lbs = 2 x 10^2 lbs = 2.0 x 10^2 lbs = 2.00 x 10^2 lbs

- place markers are ambiguous

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Scientific Notation

Only sig figs are written. All digits that are written are significant.

1.200 x 10^4 – 4 sig figs

1.0205 x 10^{-1} – 5 sig figs

No ambiguity ever remains!

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How many significant figures are there in the number 0.006410?

Preceding zeroes are NEVER significant.

Trailing zeroes are significant IF YOU DON'T NEED THEM.

Slide 44

SI units and Latin prefixes

Sometimes, SI units are written with a prefix indicating a different order of magnitude for the unit.

For example, length should always be measured in meters, but sometimes (for a planet) a meter is too small and sometimes (for a human cell) a meter is too large

Slide 45

Latin Prefixes

M = Mega = 1,000,000 = 10^6
k = kilo = 1,000 = 10^3
c = centi = 1/100 = 10^{-2}
m = milli = 1/1000 = 10^{-3}
μ = micro = 1/1,000,000 = 10^{-6}

Slide 46

To date

1. Accuracy
   1. Sig figs tell you how well you know the value of something
   2. Scientific notation allows you to express it unambiguously.

Slide 47

Units! Units! Units!

What is it?

length, volume, weight, energy, charge…

How big is it?

inches? Feet? Yards? Miles? Parsecs?

nm, cm, m, km, Mm, Gm

What else could it be?

It's a foot long, what does it weigh?

It's a gallon big, what does it weigh?

Etc.

Slide 48

Prefixes & Units

So, if I measure a planet and determine it to be 167,535 meters in circumference, this can be written a number of ways.

167535 m

1.67535×10^5 m

167.535×10^3 m = 167.535 km

Slide 49

Other systems

The metric system isn't the only system of measurement units. Any arbitrary system of units could be used, as long as the specific nature of each unit and its relationship to the physical property measured was defined.

The "English units" we use in the USA is an example of another system of units.

Slide 50

Converting Between Systems

If two different units both apply to the same physically measurable property – there must exist a conversion between them.

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Converting Between Systems

If I am measuring length in "Joes" and Sandy is measuring length in "feet" and Johnny is measuring length in "meters", since they are all lengths there must exist a reference between them.

I measure a stick and find it to be 3.6 "Joes" long. Sandy measures it and finds it to be 1 foot long, while Johnny measures it and finds it to be 0.3048 meters long.

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Conversion factors

That means:

1 ft = 3.6 Joes
1 ft = 0.3048 m

This would apply to any measurement of any object

Slide 53

Dimensional Analysis

Also called the "Factor-label Method".

Relies on the existence of conversion factors.

By simply converting units, it is possible to solve many simple and even mildly complex problems.

Slide 54

UNITS! UNITS! UNITS!

It's always all about the units!

Slide 55

Conversion Factors

IT IS THE POWER OF ONE!

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Conversion Factors

Dimensional analysis treats all numerical relationships as conversion factors of 1, since you can multiply any number by 1 without changing its value.

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1 foot = 12 inches

This is really two different conversion factors – two different “ones”

$$\frac{1\ foot}{12\ inches} = 1$$

$$\frac{12\ inches}{1\ foot} = 1$$

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One is Most Powerful

"One" is the multiplicative identity – you can multiply any number in the universe by 1 without changing its value.

Multiplying by 1 in the form of a ratio of numbers with units will NOT change its value but it WILL change its units!

Slide 59

The simplest Example

I am 73 inches tall, how many feet is that?

- I know you can do this in like 10 seconds, but HOW do you do it?

Slide 60

The Path

The first thing you need to ask yourself in any problem is….?

What do I know?

The second thing you need to ask yourself in any problem is…?

What do I want to know? (Or, what do I want to find out?)

Slide 61

The Path

The solution in any problem is a question of finding the path from what you know to what you want to know.

In a dimensional analysis problem, that means finding the conversion factors that lead from what you know to what you want to know.

Slide 62

The simplest Example

I am 73 inches tall, how many feet is that?

The thing I know - START

$$73\ inches\ \frac{???}{???} = ?\ feet$$

The thing I want - FINIS

THE PATH – how I get from START to FINISH

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The Path

$$73\ inches\ \frac{???}{???} = ?\ feet$$

The first step in ANY problem is always half-obvious!

Whatever I'm going to do next, I need to get rid of "inches". [I don't want it, it needs to change!]

$$73\ \text{inches}\ \frac{???}{?\ \text{inches}} = ?\ \text{feet}$$

The path can have 1 step or a thousand steps. The 1 step solution is always obvious (although you may not know it). I change the unit I have into the unit I want.

$$73\ \text{inches}\ \frac{?\ \text{feet}}{?\ \text{inches}} = ?\ \text{feet}$$

Slide 64

The Path

$$73 \text{ inches} \frac{? \text{feet}}{? \text{ inches}} = ? \text{feet}$$

In this case, I know the conversion: 1 foot = 12 inches

$$73 \text{ inches} \frac{1 \text{feet}}{12 \text{ inches}} = 6.08 \text{ feet} \approx 6.1 \text{ feet}$$

Only 2 significant figures! How do I know? Hang around for 10 minutes and I'll tell you.

Slide 65

The Path

If I didn't know the 1-step path, I need to find a longer path, but each step along the way is identical. I eliminate ONE unit and create a NEW UNIT.

$$= 73 \text{ inches} \frac{?\,mm}{?\text{ inches}} \frac{?\,miles}{?\,mm} \frac{?\,yd}{?\,miles} \frac{?\,feet}{?\,yd} = ?\text{ feet}$$

It's really just a whole series of multiplications by 1!

Slide 66

Too Simple?

- As simple as that seems, the problems don't get any more difficult! There is more than 1 step, many different conversion factors, but the steps in solving the problem remain the same.

Slide 67

Dimensional Analysis

1. Ask yourself what you know – with UNITS!
2. Ask yourself what you need to know – with UNITS!
3. Analyze the UNITS! change required.
4. Consider all the conversion factors you know (or have available) involving those UNITS!
5. Map the path.
6. Insert the conversion factors.
7. Run the numbers.
8. Celebrate victory!

Slide 68

Another Example

- If there are 32 mg/mL of lead in a waste water sample, how many pound/gallons is this?

Do we recognize all the units?

mg = 10^{-3} g
mL = 10^{-3} Liters

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Another Example

- If there are 32 mg/mL of lead in a waste water sample, how many pound/gallons is this?

How would we solve this problem? What's the first thing to do?

Slide 70

Dimensional Analysis

What do you know?

$$\frac{32\ mg\ lead}{mL\ water}$$

What do you want to know?

$$\frac{lb\ lead}{gal\ water}$$

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Dimensional Analysis

The path?

$$\frac{32\ mg\ lead}{mL\ water} ???? = \frac{?\ lb\ lead}{gal\ water}$$

Do you know a single step path?

Probably not, but what do we know?

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Dimensional Analysis

$$\frac{32\ mg\ lead}{mL\ water} ???? = \frac{?\ lb\ lead}{gal\ water}$$

mg measures mass of lead, lb measures weight of lead (same thing at sea level)

mL measures volume of water, gal measures volume of water

It makes sense that identical types of quantities are most easily converted into each other.

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Slide 73

Two Step Path

$$\frac{32\ mg\ lead}{mL\ water} \times \frac{?\ lb}{mg} \times \frac{?\ mL}{gal} = \frac{?\ lb\ lead}{gal\ water}$$

Do I know those 2 “single steps”?

Maybe I do, maybe I don’t. If I do, I can plug them right in. If not, I need to break them down into more steps.

Slide 74

One possible path

$$\frac{32\ mg\ lead}{mL\ water} \times \frac{1000\ mL}{1\ L} \times \frac{1\ L}{1.057\ qt} \times \frac{4\ qt}{1\ ga} = \frac{121097\ mg\ lead}{gal\ water}$$

I’ve got the right units for water. Now, I need the right units for lead.

$$\frac{121097\ mg\ lead}{gal\ water} \times \frac{1\ g}{1000\ mg} \times \frac{1\ lb}{453.6\ g} = \frac{0.26697\ lb}{gal}$$

How should this number be expressed?

It SHOULD be written as 0.27 lb/gal, because only those two digits are significant. To write it as 0.26697 lb/gal implies that you know this number to 1 part in 100,000 rather than the 1 part in 100 that you really know.

Slide 75

Sig Figs in a Calculated Answer

- Significant Figures represent the accuracy of a measurement – what if the answer isn’t measured but calculated?
- The calculated value must come from know values. These known values have accuracy of their own. Accuracy = sig figs
- You can determine the accuracy (sig figs) of a calculated value based on the accuracy of the values used to do the calculation.

Slide 76

Calculating Sig Figs

2 different rules exist:

Multiplication/Division - the answer has the same number of sig figs as the digit with the least number of sig figs

Ex. 1.0 x 12.005 = 12

Addition/Subtraction - the answer has the same last decimal place as all digits have in common

Ex 1.1 + 2.222 + 13.333 = 16.7 (16.655 rounded)

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Helpful Hints

- When adding numbers in scientific notation, be sure the decimal points are in the proper place
- You can only add numbers that have the SAME UNITS!

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Sample Problem

$$6.24 \times 10^{-3} * 1.2406 \times 10^{4} * 6 = 464.48064 \approx 5 \times 10^{2}$$

- only 1 sig fig because of the "6"
- I write the answer in scientific notation so I don't need zeroes as place markers (500)

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Sample Problem

$$1.27 \times 10^2 + 1.6 \times 10^3 + 6.579 \times 10^5 = 659627$$

How many sig figs? I don't know!
Line 'em up relative to the decimal point:

			1	2	7.
		1	6	?	?.
6	5	7	9	?	?.
6	5	9	6	2-ish	7-ish

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Slide 80

Sample Problem

(6.24×10^{-3} * 1.2406×10^4) + 1.27×10^2 =

This problem involves both addition & multiplication!?!?!?

Simply apply each rule separately (obeying normal orders of operation) - BUT DON'T ROUND UNTIL THE END or you will introduce rounding errors.

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(6.24×10^{-3} * 1.2406×10^4) + 1.27×10^2 =

First the multiplication (order of operations):

$$6.24 \times 10^{-3} * 1.2406 \times 10^4 = 7.741344 \times 10^1$$

But it's only 3 sig figs (multiplication rule):

$$(7.74_{1344} \times 10^1) + 1.27 \times 10^2 = 204.41$$

How many sig figs? Line 'em up!

	7	7.	4	1	3
1	2	7.	?	?	?
2	0	4.	4ish	1ish	3ish

So the "ones' place" is the last significant position.

So I write it as "204" or "2.04x10^2".

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Units and Math

You can multiply together any two numbers you want:

My height is 73 inches, my weight is 100 kg

73 inches * 100 kg = 7.3×10^3 kg-inches

When you multiply, the units combine.

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Addition/Subtraction and Units

You CAN'T add any two numbers, because the units don't mix:

73 inches + 100 kg = 173 ????

To add two numbers, they MUST have the same units!

Slide 84

I have 48 cents in my pocket and $32 in my wallet. How much money do I have.

I can't just add them together:
48 cents + 32 dollars = 80 ???

But I can if I give them the same units:

$$48 \text{ cents} * \frac{1 \text{ dollar}}{100 \text{ cents}} = 0.48 \text{ dollars}$$

32 dollars + 0.48 dollars = 32.48 dollars (or $32.48)

Slide 85

Same type – different units

All of the conversions we've done so far have been simply changing the unit of measure without changing the type of measurement.

Inches to feet. Inches measures length. Feet measures length.

mL to L to quarts to gallons. All measure volume.

That's great but kind of boring. I mean, I don't get any taller if I use inches instead of feet. I don't know anything new.

Slide 86

Different unit. Different type.

OOOOO….NOW WE'RE TALKING!

Here's some real chemistry. If I can change a unit of mass into a unit of length, I've learned something new! But I need to have some physical relationship between length and mass for that to work.

Slide 87

The most important chemical conversion!

$$poop \frac{???}{???} = gold$$

Sadly, there's no known relationship between poop and gold…at least not yet!

Slide 88

What is Density?

Density is the mass to volume ratio of a substance.

It allows you to compare the relative “heaviness” of two materials. A larger density material means that a sample of the same size (volume) will weigh more.

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Ratios are Conversion Factors

Density is the ratio of mass to volume.

So, if you want to convert mass to volume or volume to mass – it’s the DENSITY!

Slide 90

$$Density\ of\ steel = \frac{3\ g\ steel}{mL\ steel}$$

It means 1 mL of steel has a mass of 3 g:

1 mL steel = 3 g steel

Slide 91

Equalities are ratios – Conversion factors

1 mL steel = 3 g steel

$$\frac{1\ mL\ steel}{3\ g\ steel} = 1$$

$$\frac{3\ g\ steel}{1\ mL\ steel} = 1$$

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Conversion Factors

Powers of 1

Slide 93

Sample problem

The density of aluminum is 2.7 g/mL. If I have a block of aluminum that is 1 meter on each side, then what is the mass of the block?

Where do we start?
We know the volume (length*width*height):
1 m x 1 m x 1 m = 1 m^3

Where do we want to go?
Grams (or kilograms or cg or some unit of mass!)

Slide 94

Algebraically…

D = <u>mass</u>
Volume

$$D = \frac{\text{mass}}{\text{Volume}}$$

But this is really just another conversion factor!

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1 m^3 * ???? = ? g

How do we go from m^3 to g?

m^3 is volume. g is mass. As soon as both are involved, there's a density somewhere!

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$$1\ m^3 \frac{2.7\ g}{mL} = ?\ g$$

That won't quite work – we need to get m^3 to mL so the mL will cancel.

Turns out 1 mL=1 cm^3. And 100 cm=1 m, so…

$$1\ m^3 = 1\ m \times m \times m \frac{100\ cm}{1\ m} \frac{100\ cm}{1\ m} \frac{100\ cm}{1m} \frac{1\ mL}{1\ cm^3} \frac{2.7\ g}{1\ mL} = 2.7 \times 10^6 g\ Al$$

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Building Blocks of Matter

- Chemistry is the study of **matter** - which is anything that has mass and takes up space. In other words, Matter is ANY-THING.
- Matter itself has a wide variety of properties. What these properties are and how these properties can be changed is important to the function of everything from a rock to a human being.

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Divisible vs. Indivisible

The world we see around us appears to be quite divisible – it can be divided into pieces of the whole.

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Slide 99

Divisible vs. Indivisible

- Consider a tree. It's made of "wood". But, what is wood?
- Chop down a tree, you can make a 2x4 board. A 2x4 is a piece of a tree.
- Cut up the 2x4, you can make toothpicks. Toothpicks are pieces of a 2x4 which is a piece of a tree.
- Grind up a toothpick, you get sawdust. Sawdust is a piece of a toothpick which is a piece of a 2x4 which is a piece of a tree.
- Things in nature are DIVISIBLE! But not infinitely so.

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Slide 100

Molecules

- A **molecule** (chemical compound) is the smallest unit of matter that maintains the identity of the parent. For glucose (sugar), the glucose molecule is the smallest unit of sugar that would still taste sweet. For wood, the molecule is cellulose.
- Molecules are made up of even smaller units called **atoms (elements)**. An atom is indivisible by any normal chemical or physical means. (To split it, you need to use nuclear means such as a high energy particle accelerator).

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Slide 101

Molecules

- Chemistry is all about how you arrange and rearrange atoms to make different molecules. Chemistry is also about the **physical properties** of the molecules themselves.
- Biology, Biochemistry, Materials Science, polymer science, engineering, and a wide variety of other disciplines all rely on Chemistry's ability to create and measure the properties of molecules.

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Slide 102

The Chemical vs. The Physical

- When we talk about the "physical properties" of materials, we are talking about molecules. Molecules are the smallest, indivisible units of matter that maintains the identity (and most properties) of that matter.
- When we talk about the "chemical properties" of materials, we are talking about atoms. Chemistry is often defined as the making or breaking of bonds to rearrange the atoms in a molecule.

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What if you have more than 1 type of molecule?

What's the difference between sugar-water and sugar?

Sugar is dry	Sugar-water is wet
Sugar is sweet	Sugar-water is sweet
Sugar melts if heated	Sugar-water boils

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Both have sugar, but…

Sugar (glucose) is a single type of molecule.

Sugar-water is a **mixture** of sugar molecules and water molecules.

A mixture usually has some properties that are different from either of its substituents. It might also share a few: sugar-water and water are both wet. Sugar-water and sugar are both sweet.

But boiling point of sugar-water is different than the boiling point of sugar and the boiling point of water.

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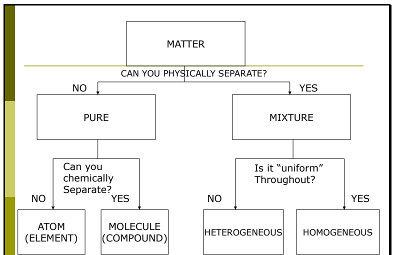
Slide 105



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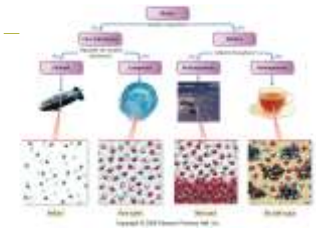

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Slide 107

What is it?

Sugar-water

mixture

Made up of water and sugar

Homogenous mixture

Each part of the pitcher is identical: there is some water and some sugar, it is clear and colorless

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Slide 108

What is it?

Mayonaisse

mixture

Made up of eggs and oil and water and…???

Homogenous mixture

Each part of it is identical: it is white and smooth

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Slide 109

What is it?

Sweet Relish

mixture

Made up of pickles and water and sugar and peppers and corn

Heterogenous mixture

You can see the difference between the pickles and the peppers and between the peppers and the corn.

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Slide 110

Questions???

It's all about being able to ask the questions and then finding the answers.

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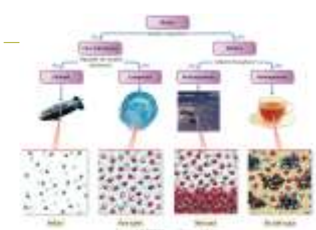

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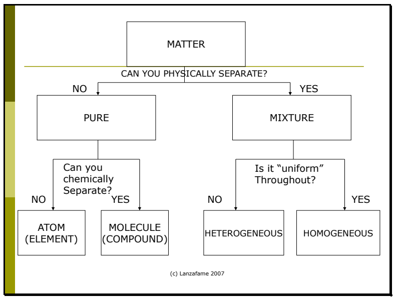

Slide 113

Question

Consider a glass of Coke with no ice cubes. It is…

A. A pure substance
B. An element
C. A homogeneous mixture
D. A heterogeneous mixture

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Question

Consider chocolate pudding:

A. A pure substance
B. An element
C. A homogeneous mixture
D. A heterogeneous mixture

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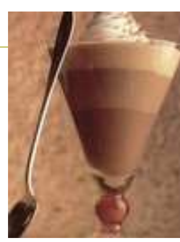

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Slide 118

Question

Consider a hamburger:

A. A pure substance
B. An element
C. A homogeneous mixture
D. A heterogeneous mixture

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Apple juice

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Summary

Chemistry is about every Thing.

"Things" can be pure substance (elements or compounds) or mixtures (heterogeneous or homogeneous)

Chemistry is concerned with the measurement and understanding of the chemical and physical properties of materials.

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Slide 123

A word about Energy…

Energy is a difficult concept to define. It is often easier to define it in terms of what it does rather than what it is.

Energy, difficult as it is, is a critical concept underlying the physical sciences because energy provides the impetus for changes.

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Energy

Energy is often defined as "the capacity to do work". So, it is usually the work being done that you see.

Work is "the action of a force through a distance".

So, if I push a chair 10 feet across the floor. My force (push) acting over a distance (10 feet) is work. The food I eat and its subsequent metabolism provides "capacity to do work" (energy).

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Energy = kinetic energy + potential energy

Kinetic energy is energy of motion (my moving chair)

Potential energy is stored energy (food – chemical potential energy)

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Conservation of Energy

Energy is neither created nor destroyed, it simply changes form.

So, if I look at a **system** (collection of things), the total energy (kinetic+potential) should be constant at all times.

The only way to get energy into a system is to do work on it.

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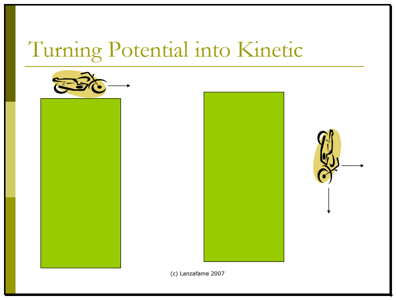

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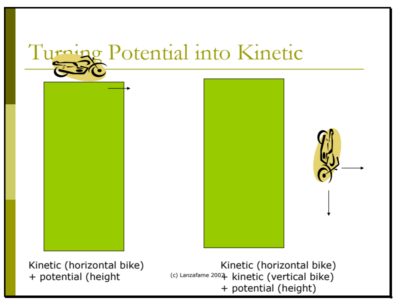

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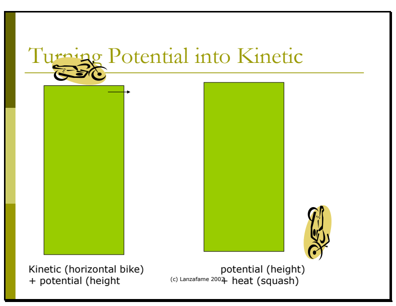

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At ALL times, the total energy in the system is conserved (remains the same).

Total = kinetic + potential + heat

Heat is actually molecular kinetic energy

If you wanted to change the amount of energy in the system, you'd need to do WORK to add or subtract energy from the system (for example, carry the wrecked bike back up to the roof).

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Slide 131

Chemical Energy

We will, at various times, explore the energy changes involved in molecular interactions (sadly, we don't get to throw things off the building – we leave that to physicists.)

Stored chemical energy is a form of potential energy

Molecular motions are kinetic energy (heat)

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