CHEM 103

Macroscopic

↳ Particle Level

↳ Symbolic

Lecture Notes
January 24, 2006
Prof. Sevian

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Thinking like a Chemist

- Macroscopic
  - Matter that comprises everything
  - Properties of materials
- Particle level
  - Structure of matter
  - Energy that governs interactions of particles
- Symbolic
  - Ways of representing behavior of matter

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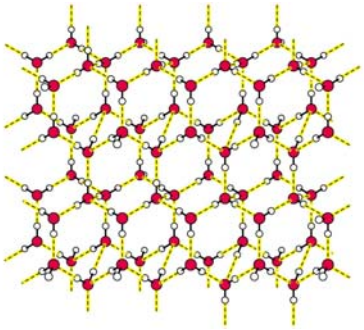
Example: Ice (solid water)

Particle Level Understanding



Macroscopic Understanding

Symbolic Representation

H_2O (*s*)

Ice crystal structure picture from
http://cwx.prenhall.com/horton/medialib/media_portfolio/text_images/FG02_05.JPG

What Kind of Information?

- Macroscopic: iceberg has properties
  - Appears white
  - Floats on water
- Particle level: ice structure explains
  - Regular, repeating lattice structure
  - What are the “holes”?
- Symbolic: H_2O (*s*) explains
  - Basic formula: two H for every one O
  - Solid phase

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Macroscopic Understanding

What are some properties of ice?

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What kinds of properties?

- It melts at 32^{o}F
- It's cold (what does this mean?)
- It cools down a hot drink
- It tastes like water
- It has no odor
- It is used to put out fires
- It soaks into most things (wets them)
- Lots of materials can dissolve in it
- Ice floats in liquid water

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Macroscopic Understanding

Physical properties

observed and measured without changing the composition of a material (*e.g.*, color, odor, hardness, density, melting temperature)

Chemical properties

involve a change in composition of the material (*e.g.*, flammability, reactivity)

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Properties can be…

Extensive

depend on the amount of material present (*e.g.*, mass, volume, weight)

Intensive

independent of the amount of material present (*e.g.*, density, chemical composition)

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Ice: What can we observe?

- It melts at 32^{o}F
- It's cold (it feels cold to the touch)
- It cools down a hot drink
- It tastes like water
- It has no odor
- It is used to put out fires
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Why is this important?

- Intensive properties can be used to identify a material, extensive properties cannot
- Intensive properties have predictive power, extensive properties do not
- Physical properties depend on the organization of the particles that comprise the matter
- Chemical properties depend on energy considerations when one kind of matter interacts with another

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Think-Pair-Share

A sample of ethanol	Intensive or extensive?	Chemical or physical?
Boils at 79 ºC		
Fills a volume of 200 mL		
Does not react with water		

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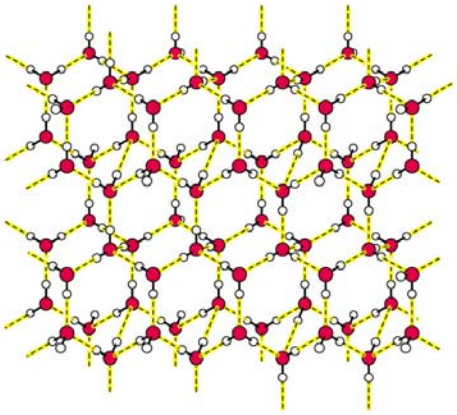
Particle Level Understanding

How does a particle level understanding explain some properties of ice?



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Ice Structure

- H-O-H bond angles and attraction between one water's H and another's O give rise to regular, repeating hexagonal pattern → Ice is a solid up to 0ºC
- Solid structure is more "expanded" than liquid → Ice floats in liquid water
- Distances between some water molecules are close to the wavelength of visible light waves → Snow appears white

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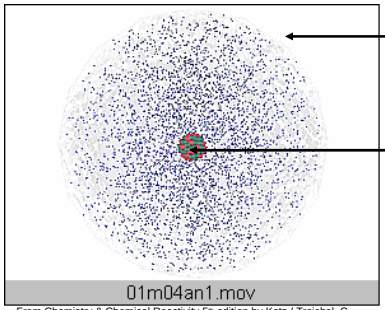
Particle Level Understanding

Matter is composed of atoms

What is an atom?



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Note: Not drawn to scale!

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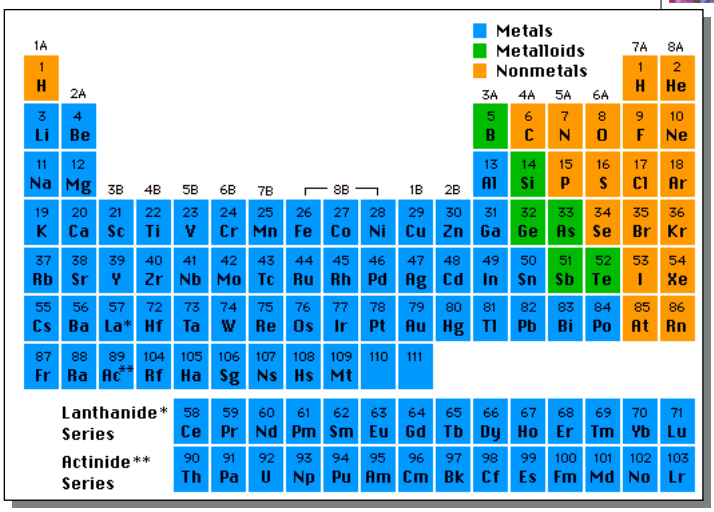
How many kinds of atoms?



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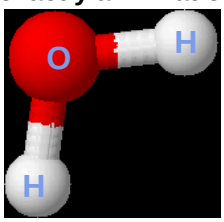
Particle Level Understanding

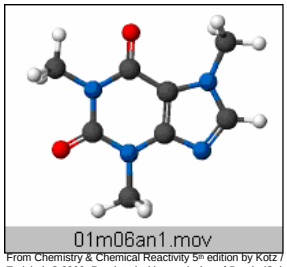
Matter is composed of atoms.

Therefore, it can be broken down into atoms.

Water (H_2O) can be broken into hydrogen (H) and oxygen (O), which are present in exactly a 2:1 ratio.



Caffeine ($C_8H_{10}N_4O_2$) can be broken into carbon (C), hydrogen (H), nitrogen (N), and oxygen (O), which are present in exactly an 8:10:4:2 ratio.



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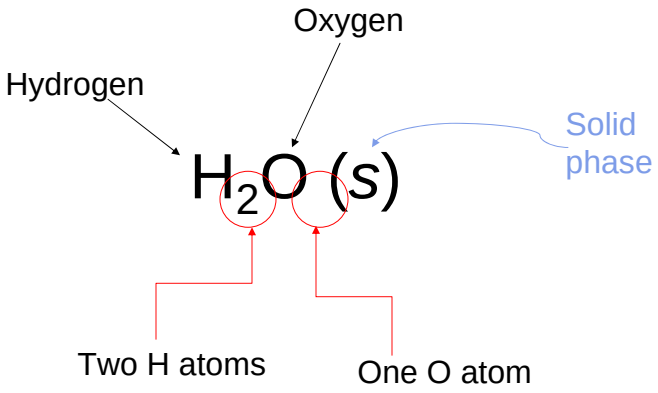
Symbolic Representation

What information does the formula contain?



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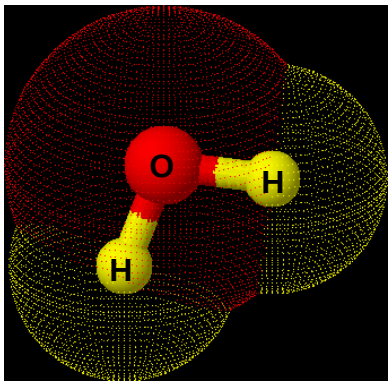
What hidden information does a symbol contain?



Each unit (molecule) of H_2O has:

One O atom (red)

Two H atoms (yellow)

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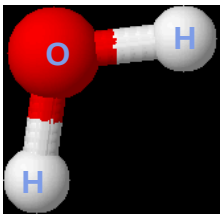
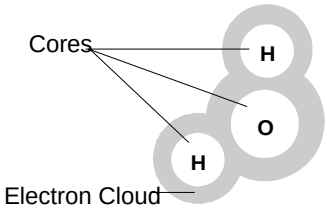
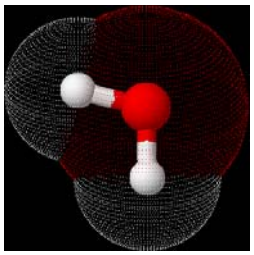
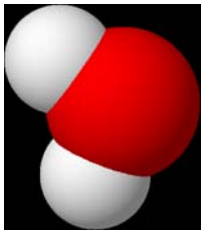
Many Symbolic Representations

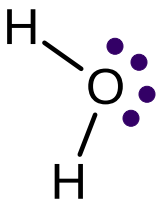






H_2O (*s*)





Macro-Particle-Symbolic

Each level provides information

- Macroscopic
  - Properties of matter
- Particle Level
  - Interactions between particles that give rise to matter's properties
- Symbolic
  - Representation of matter

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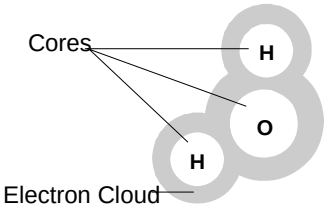
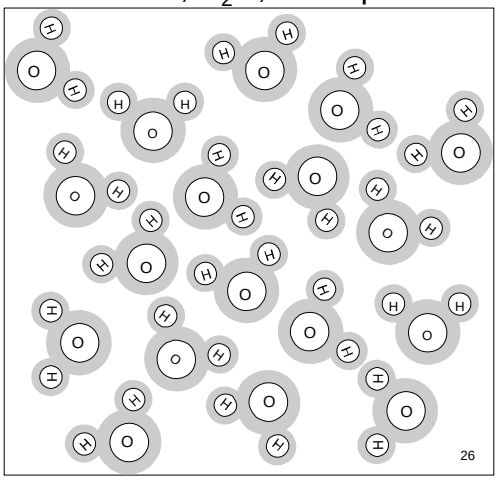
H_2O (*s*) Representation

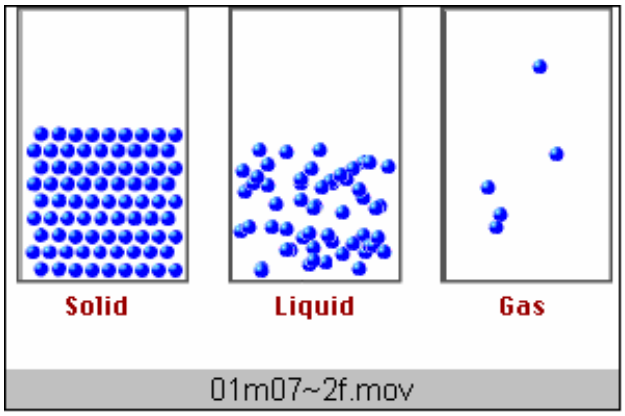
A two-dimensional picture of several units of water, H_2O, in a liquid state



A single molecule (unit) of water, H_2O



States (Phases) of Matter



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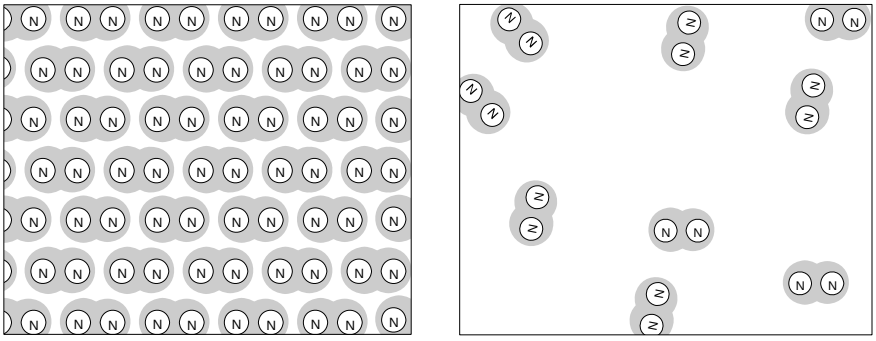
Solid vs. Gaseous N_2



N_2 (*s*) N_2 (*g*)

Note: Not drawn to scale. True density of a gas is about 1/1000th of solid.

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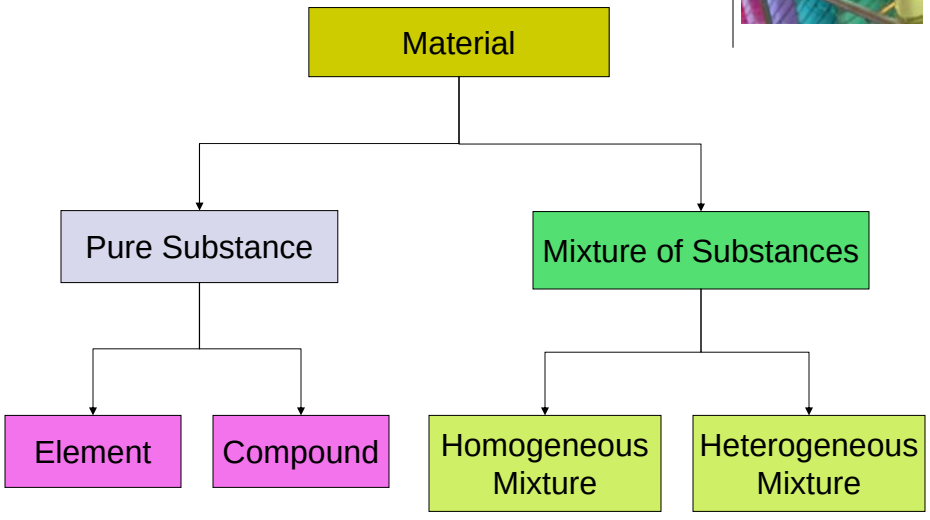
Other Categorizations of Matter



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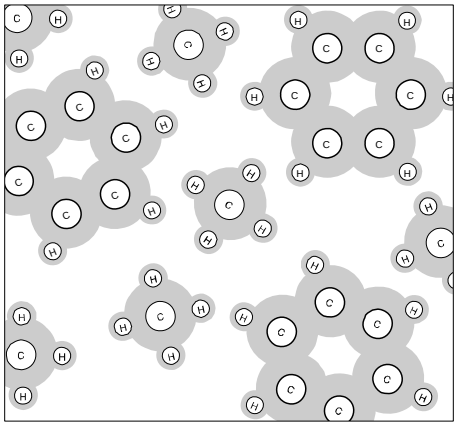
Practice #1



Pure substance or mixture?

Element or Compound?

Homogeneous or Heterogeneous?

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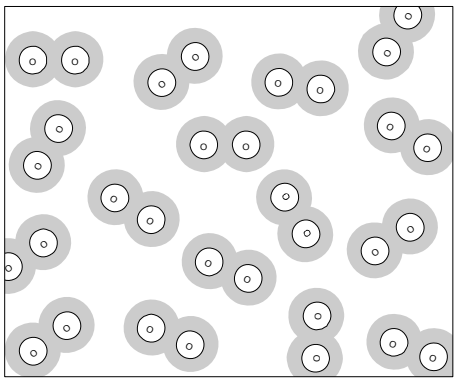
Practice #2



Pure substance or mixture?

Element or Compound?

Homogeneous or Heterogeneous?

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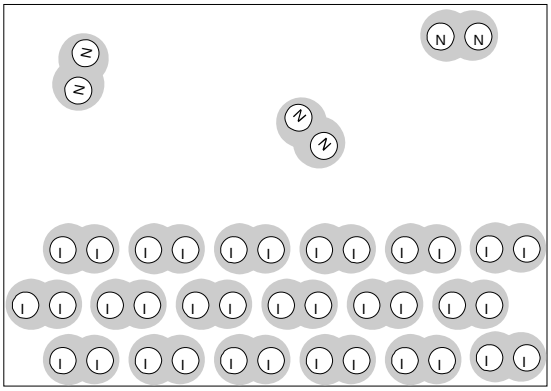
Practice #3



Pure substance or mixture?

Element or Compound?

Homogeneous or Heterogeneous?

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Please bring your calculator to class on Thursday (and from now on)

Chem 103
Prof. Sevian

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