CHEM 115 – Chemical Principles I

Macroscopic

↳ Particle Level

↳ Symbolic

Lecture 1

Prof. Sevian

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Chem 115 Course Information FAQs

- Course website: link from UMB chemistry department website www.chem.umb.edu
- Lab is a separate co-requisite course (Chem 117) and starts on the second week of classes
- Homework does not get turned in, but if you do not do the homework then you will not pass the course
- Discussion attendance counts as part of the grade – discussion is on a Friday-Tuesday-Thursday schedule and begins this Friday
- You will need an i>clicker to bring to lecture – clicker questions count toward your grade and can only be answered by using your clicker during lecture (the lowest 5 clicker grades will be dropped)
- There are three midterm exams and a final exam that is comprehensive – there are no makeup exams (the lowest exam grade will be dropped)
- Copies of the text book and homework solutions manual are on reserve at Healey library
- All students in Chem 115 must take a pre-test and a post-test (they count toward your grade), which will be given during the first hour of Chem 117 labs during the weeks of Feb 9-11 (pre-test) and May 4-6 (post-test) – if you are not enrolled in lab you must take the pre-test and post-test during one of those times, or make separate arrangements with me to take it before the end of those weeks

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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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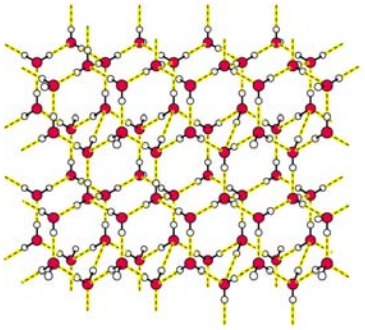
Example: Ice (solid water)

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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Properties are statements about observations that you can make

Sometimes observations (measurements) can be made with your eyes, and sometimes they require instruments

- It melts (changes from solid to liquid) at 32^{o}F
- It's cold (what does this mean? It feels cold)
- It cools down a hot drink
- It tastes like water
- It has no odor
- It can be split, using electricity, into hydrogen and oxygen gases
- When melted, it soaks into most things (wets them)
- Lots of materials can dissolve in melted ice
- Ice floats in liquid water

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Macroscopic Understanding

<u>Physical properties</u>

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

<u>Chemical properties</u>

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)

since intensive properties do not depend on the amount of material, they are useful for identifying an unknown material

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Properties are statements about observations that you can make

Are these properties chemical or physical? *

Are these properties intensive or extensive? **

- It melts (changes from solid to liquid) at 32^{o}F
- It's cold (what does this mean? It feels cold)
- It cools down a hot drink
- It tastes like water
- It has no odor
- It can be split, using electricity, into hydrogen and oxygen gases
- When melted, it soaks into most things (wets them)
- Lots of materials can dissolve in melted ice
- Ice floats in liquid water

Key Question: Does it change composition (identity)?

****Key Question: Does it matter how much of the material there is?***

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		
Is flammable		

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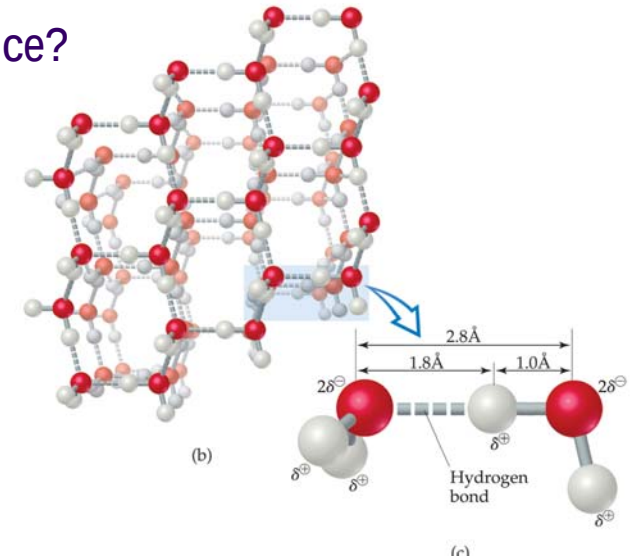
How does a particle level understanding explain some properties of ice?

Particle Level Understanding



Ice Structure

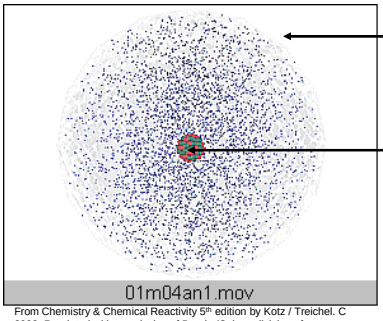
- H-O-H bond angles and attraction between one water's H and another's O give rise to regular, repeating hexagonal pattern
  → Ice is a solid up to 0ºC
- Solid structure is more "expanded" than liquid
  → Ice floats in liquid water
- Distances between some water molecules are close to the wavelength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

(a)

Particle Level Understanding

Matter is composed of atoms

What is an atom?



Note: Not drawn to scale!

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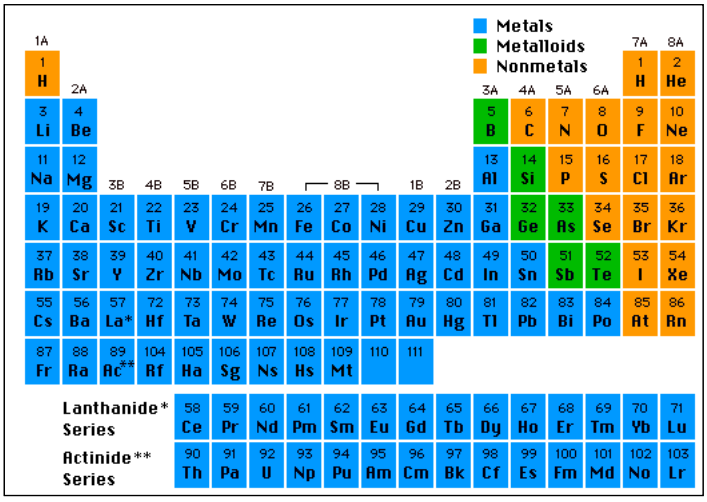
How many kinds of atoms?



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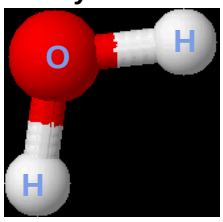
Particle Level Understanding

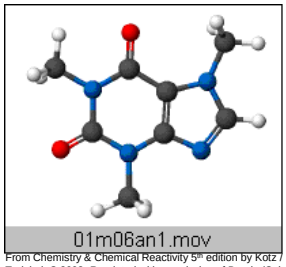
Matter is composed of atoms.

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.

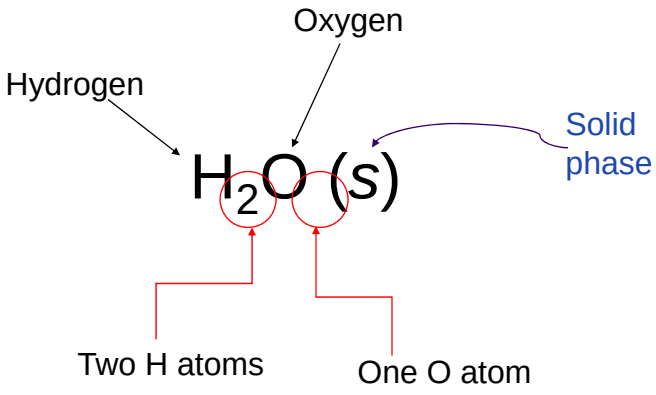


Caffeine ($C_8H_{10}N_4O_2$) can be broken into carbon (C), hydrogen (H), nitrogen (N), and oxygen (O), which are present in exactly an 8:10:4:2 ratio.

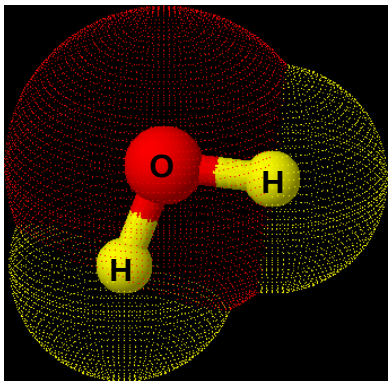


Symbolic Representation

What information does the formula contain?



What hidden information does a symbol contain?

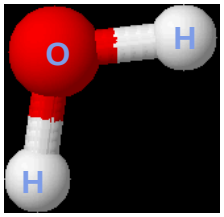


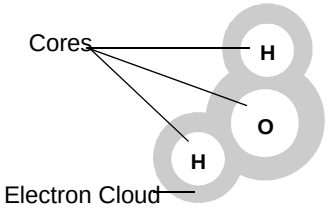
Each unit (molecule) of H_2O has:

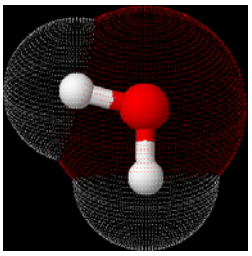
One O atom (red)

Two H atoms (yellow)

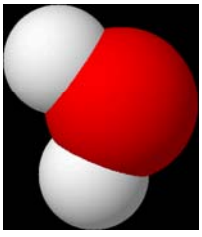
Many Symbolic Representations

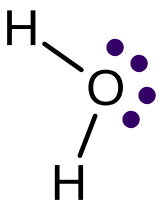




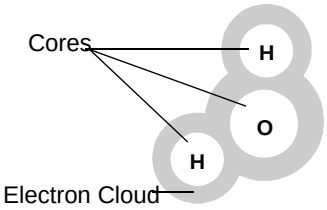


H_2O (*s*)



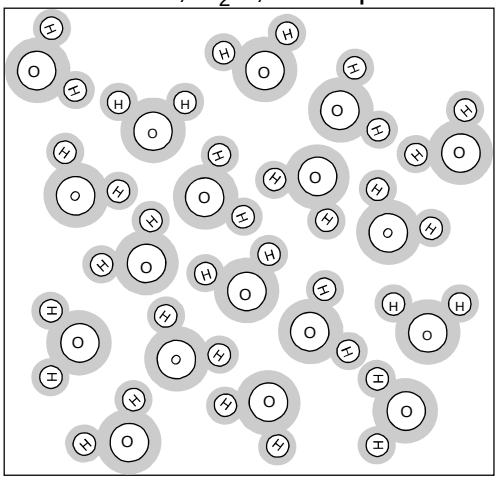


H_2O (*s*) Representation

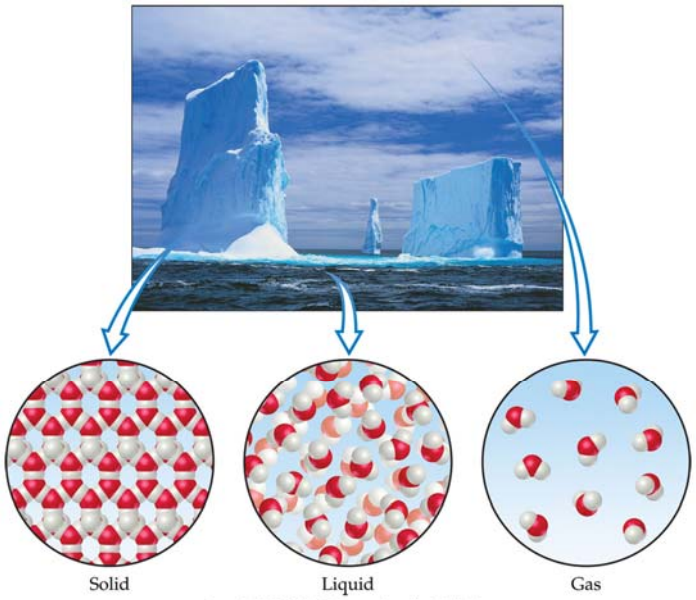


A single molecule (unit) of water, H_2O

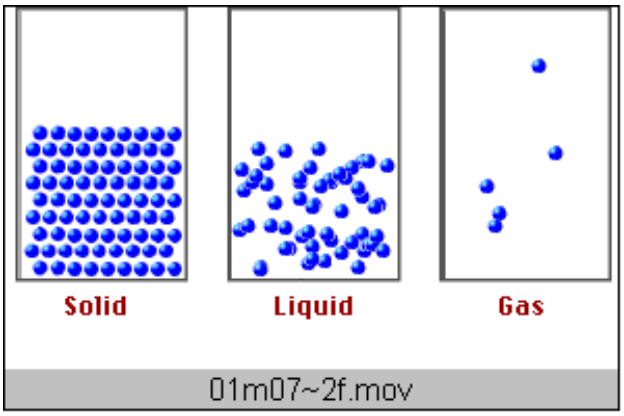
A two-dimensional picture of several units of water, H_2O, in a liquid state



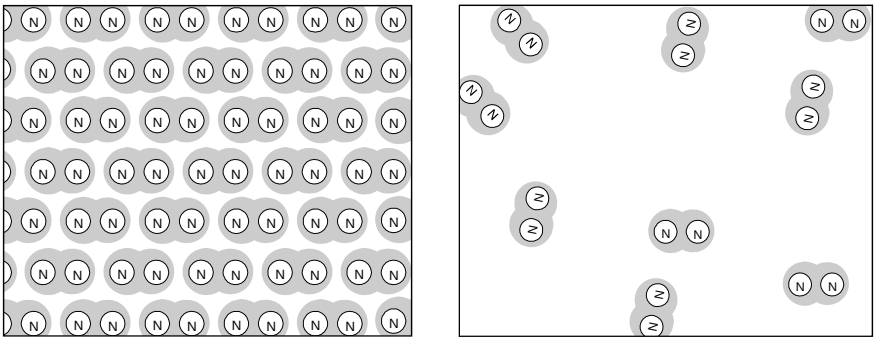
States (Phases) of Matter



States (Phases) of Matter



Solid vs. Gaseous N_2

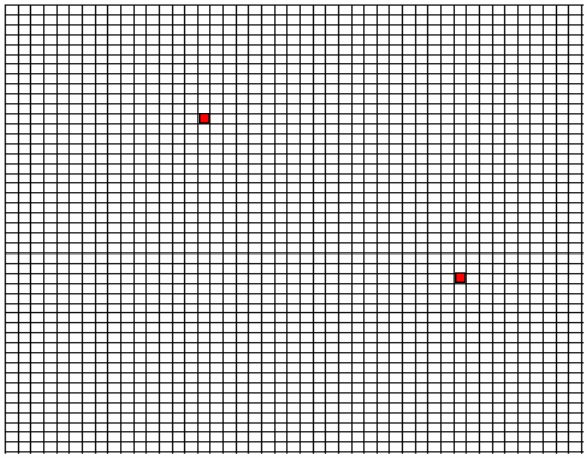


N_2 (*s*) N_2 (*g*)

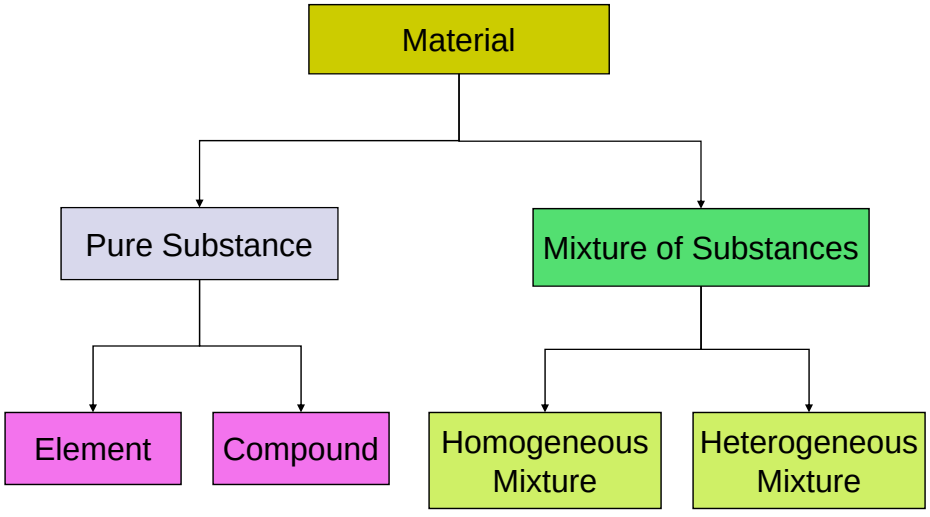
Note: Not drawn to scale. True density of a gas is about 1/1000th of solid.

Gas particles are very far apart from each other

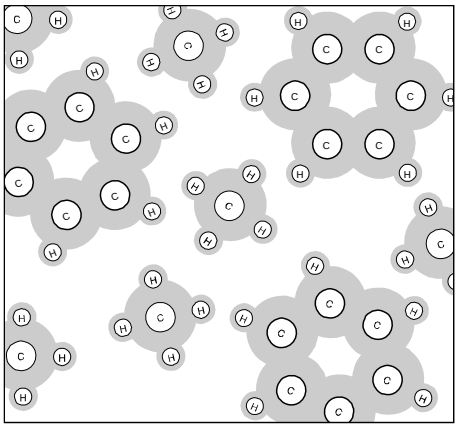
A more accurate depiction: 1 in 1000 at room temperature



Categories of Matter



Practice #1

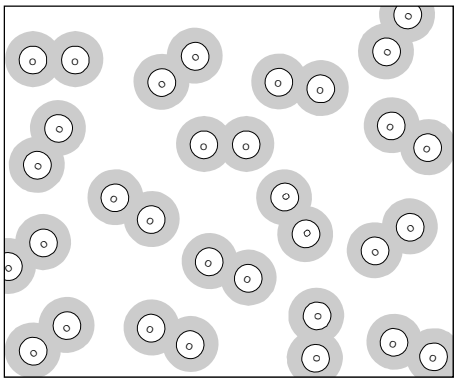


Pure substance or mixture?

Element or Compound?

Homogeneous or Heterogeneous?

Practice #2

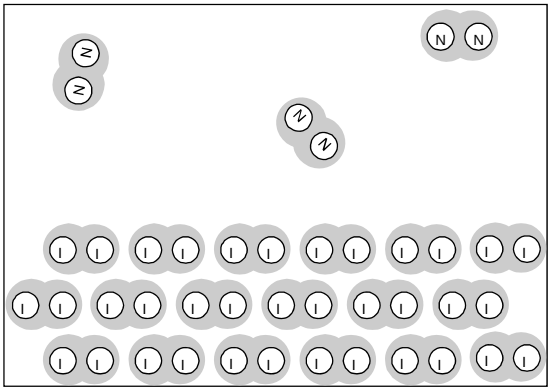


Pure substance or mixture?

Element or Compound?

Homogeneous or Heterogeneous?

Practice #3



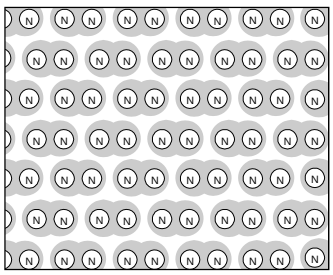
Pure substance or mixture?

Element or Compound?

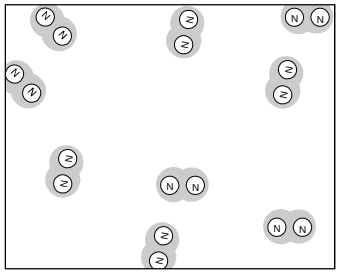
Homogeneous or Heterogeneous?

Modified from RSC

Density = A measure of concentration



N_2 (*s*)



N_2 (*g*)

Which is more dense, the solid or the gas?

Density measures how many particles (how much "stuff") are in a given volume (space). To compare two samples, you can either:

- **Compare equal volumes and then see which one has more particles (stuff) in that same volume (space)**
- **Compare equal amounts of particles (stuff) and see which one takes up more volume (space)**

Density consequences

1.00 cm^3 of liquid water has a mass of 1.00 g
1.00 cm^3 of ice has a mass of 0.92 g

What are the densities of each?
Liquid water density = 1.00 g / 1.00 cm^3 = 1.00 g/cm^3
Ice density = 0.92 g / 1.00 cm^3 = 0.92 g/cm^3

Which is less dense? Does this make sense?

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Key points from today

- Chemists think simultaneously on three levels: macroscopic, particle level, and symbolic
- Matter is made of particles
  - At the particle level, the particles do not necessarily have the same properties as the material does at the macroscopic level
- Density is:
  - A measure of concentration
  - Amount of matter per unit of volume
    - Amount of matter can be measured in grams (mass)
    - Volume can be measured in cubic distance (e.g., cm^3 or m^3) or space occupied (e.g., milliliters or liters). These are actually the same thing because 1 mL = 1 cm^3 by definition.
  - D = (mass) / (volume), most often as g/mL or g/L

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