

Chapter 13: The Molecular Model of Matter

Did you read chapter 13 before coming to class?
 A. Yes
 B. No

The grand scheme of science

Laws

Models

Physical Phenomena

Goal: Understanding (to be able to predict the future)

What is a Model?

- A useful analogy we can relate to.
- They are almost never 100% correct.
- Different models are used to describe the same thing at different levels of detail.

Models of Matter

- Continuous
- Molecular
- Nuclear
 - Solar System (Ch 14)
 - Bohr (Ch 14)
- Wave (Ch 15)
- ...

Continuous Model

- The continuous model of matter represents matter as smooth and infinitely divisible. It reflects well what appears to our naked eye, but it lacks explanatory power. Many things remain a mystery as long as we view matter in this way.

- Example: The milk drop looks continuous, but could we go on cutting it into smaller and smaller pieces indefinitely?

National Geographic

Continuous Model

- Useful in many situations:
 - Fluid dynamics
 - Classical Electrodynamics
- Has many limitations
 - Charge and light come in distinct packets
 - How do changes of state occur
 - Etc.

The Molecular Model

- All matter is made of tiny particles called molecules which are:
 - Too small to see, even with an optical microscope
 - In constant motion
 - Governed by Newton's laws of motion, energy conservation, etc.
- Each different kind of matter has a different kind of molecule

So What?

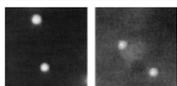
- Anybody can come up with a theory or model. The proof is in what it can explain and predict.
- So we ask, what can the molecular theory of matter explain and predict?

Brownian Motion

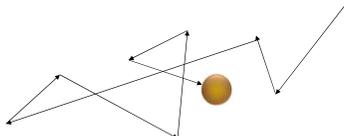
- When viewed under a microscope, large particles suspended in a fluid have an erratic, jittery motion.
 - Discovered by Robert Brown in 1827
 - Some kind of "life force"?



Brownian Motion

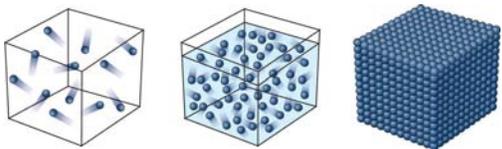


- The erratic, jittery motion of a dust speck in a fluid is strong evidence supporting the molecular model.
 - The speck is colliding randomly with unseen molecules.



States Explained

- **Solid:** The molecules are frozen in place but still vibrate.
- **Liquid:** The molecules move past each other but still have a weak attraction.
- **Gas:** The molecules only interact when they collide.
- **Plasma:** The molecules collide with enough energy to break into charged pieces.



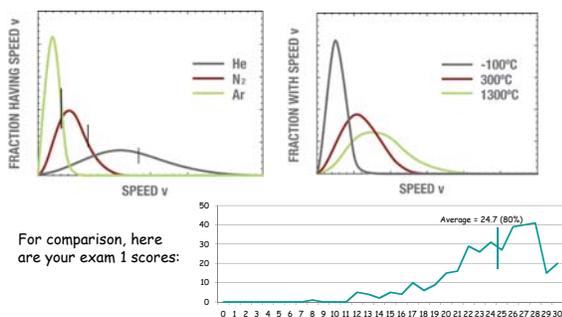
Temperature Explained

- Temperature is a measure of the average kinetic energy of the molecules.
 - Cold → slowly moving
 - Hot → rapidly moving
 - Absolute zero → motion ceases (-460 F, -273 C)
- Example: At room temperature molecules are moving about 1,000 ft/s



Pop Quiz: Why don't U of U students ever double recipes?

Temperature is a measure of the average kinetic energy of a collection of molecules



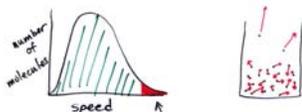
Off to the molecular races



$K.E. = \frac{1}{2} mv^2$
 the same for both NH_3 and HCl
 but HCl has about twice the mass

Evaporation Explained

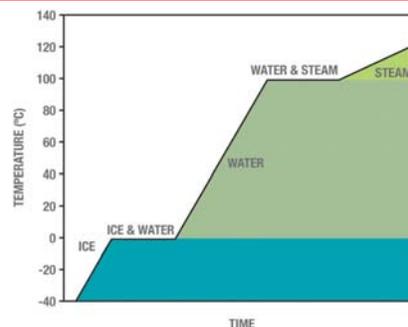
- Temperature is a measure of the average kinetic energy. Some molecules go faster and some go slower. The fast ones escape as a gas even when the average temperature is below boiling.



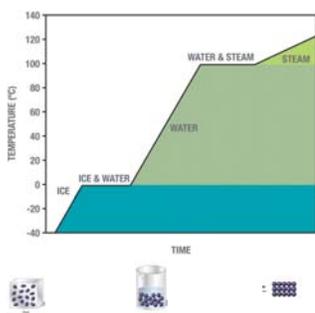
- Why are you cold when you get out of a swimming pool?
- Why doesn't sweating work in high humidity?
- Why do open containers of water freeze in the refrigerator, while closed containers do not?

State changes and the molecular model

- Temperature is molecular kinetic energy.
- Internal energy includes kinetic plus electrical potential energy from how the molecules are arranged.



Why does it get warmer when it snows?



Gas Pressure Explained

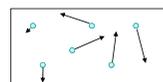
- Gas Pressure is caused by molecular collisions with the walls of the container. Like throwing a huge number of balls against a wall.
- Remember Newton's Third Law:
 - The *wall* exerts a force on the *ball*, so the *ball* exerts a force on the *wall*



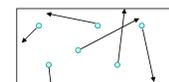
The Mechanical Universe... and Beyond
MOLECULAR MODEL OF PRESSURE
 Playing Time: 1:08

Gas Pressure and Temperature

- Gas pressure increases with temperature if the gas cannot expand. The hotter molecules hit the container walls *harder* and *more often* than the cold ones.
- Example: aerosol can in the fire



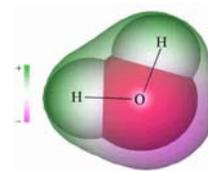
Colder



Hotter

The Mechanical Universe... and Beyond
TEMPERATURE IN THE MOLECULAR MODEL
 Playing Time: 1:02

A curious behavior of water



Some things we haven't explained

- Where does color come from?
- How are the parts of molecules arranged?
- Why does metal conduct heat well, but wood does not?
- Why does metal conduct electricity, but not wood?