

## Unit 3: Kinetic Theory, Gas Laws, Phases of Matter

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## Kinetic Theory

If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generation of creatures, what statement would contain the most information in the fewest words? I believe it is the *atomic hypothesis* (or the *atomic fact*, or whatever you wish to call it) that *all things are made of atoms--little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another*. In that one sentence, you will see, there is an *enormous* amount of information about the world, if just a little imagination and thinking are applied. –Richard Feynman

## Kinetic Theory

Some elements of the model

- Matter is made of tiny particles (atomic-molecular theory).
  - Is this a theory? Isn't it a law?
  - The atoms of antiquity (see below)
- The particles are in constant motion.
  - How do we know this? [Brownian Motion](#).
- In a fluid, collisions with container walls produce pressure effects.
- Temperature depends on average speed of particles. Hotter = Faster
- All collisions are elastic.

## Ideas of the Greek Atomists

Atomos: Greek for "uncuttable"

The big three natural philosopher atomists

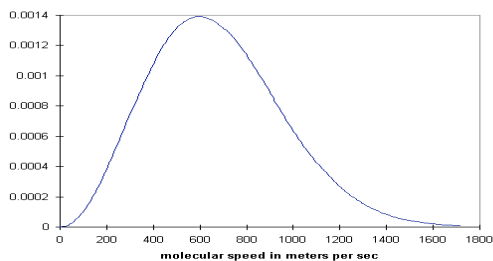
- Leucippus of Miletus ca 440 BC
- Democritus (ca 460-371 BC) of Abdera
- Epicurus (341-270 BC) of Samos

Five chief points

- All matter is composed of atoms, which are bits of matter too small to be seen. These atoms CANNOT be further split into smaller portions.
  - Epicurus: "Therefore, we must not only do away with division into smaller and smaller parts to infinity, in order that we may not make all things weak, and so in the composition of aggregate bodies be compelled to crush and squander the things that exist into the non-existent...."
- There is a void, which is empty space between atoms.
- Atoms are completely solid.
- Atoms are homogeneous, with no internal structure.
- Atoms are different in size, shape, and weight.
  - Philosophical atomism (materialism)
    - "Nothing exists except atoms and empty space; everything else is opinion." Diogenes Laertius

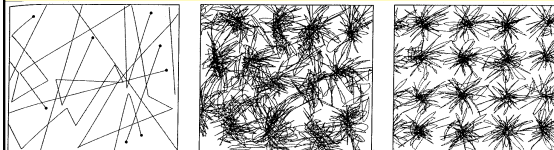
## Matter Visualization

- What does a gas look like, according to this model?
- The speed distribution curve



## Matter Visualization

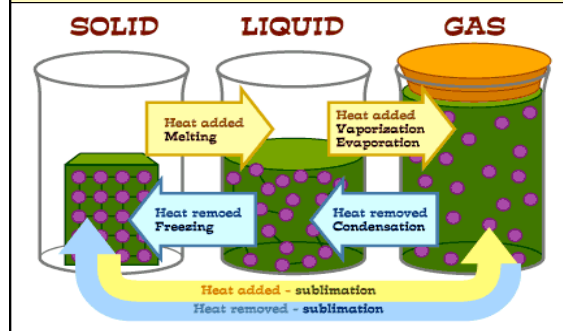
- [Gas in a Balloon applet](#)
- What features of the model explain the distinguishing characteristics of liquids and solids?
- A classroom simulation?



## Examples

1. [Molecules in Motion applet](#)
2. [Kinetic Theory Simulation applet](#)
3. The gas laws (hotter = more pressure; hotter = more volume)
  - [The Ideal Gas Law applet](#)
4. Heating closed containers can cause explosions
  - sidewalk joints
6. Gas Properties: Expansion, **Diffusion**
  - [Diffusion applet](#)
  - [Diffusion-Limited Aggregation Fractal](#)
7. Some hot water faucets turn themselves off (only once)
8. The valve on a bicycle tire gets hot when you pump it up, but not if you use a pressure hose.

## Phase Changes



## Phase Changes

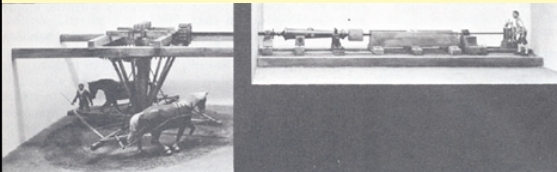
1. To change from liquid to gas, particles take along some "extra" motion
  - boiling temp maxes out
2. A gas-liquid equilibrium
  - [Evaporation applet](#)
3. Boiling is pressure dependent: why?
  - high altitude instructions
  - pressure cookers
  - **boil test tube with ice cube**
4. **Moth Balls demo**
  - heating curve for water: 80/540
  - **Fusion graph**

## Modeling Phase Changes

1. Observation: it takes a lot of "heat" to melt things or vaporize things- boiling temperature, mothballs freezing
2. Law: Phase changes require heat.
3. Models
  - Particle model: "Red Rover", springs
  - Energy model: it takes extra heat energy to effect a phase change
  - What about melting and condensation?

## The Caloric Model

- What was it?
- What was wrong with it?
  - Count Rumford- Munich, 1798



## The Caloric Model

In 1798, Count Rumford published An Experimental Enquiry Concerning the Source of the Heat which is Excited by Friction, a report on his investigation of the heat produced while manufacturing cannons. He had found that boring a cannon repeatedly does not result in a loss of its ability to produce heat, and therefore no loss of caloric. This suggested that caloric could not be a conserved "substance" though the experimental uncertainties in his experiment were widely debated.

His results were not seen as a "threat" to caloric theory at the time, as this theory was considered to be equivalent to the alternative kinetic theory.[3] In fact, to some of his contemporaries, the results added to the understanding of caloric theory.

Rumford's experiment inspired the work of James Prescott Joule and others towards the middle of the 19th century. In 1850, Rudolf Clausius published a paper showing that the two theories were indeed compatible, as long as the calorists' principle of the conservation of heat was replaced by a principle of conservation of energy. In this way, the caloric theory was absorbed into the annals of physics, and evolved into modern thermodynamics, in which heat is the kinetic energy of molecules.

-Wikipedia