Atomic Theory
&
Atomic Structure

Early Atomic Theories

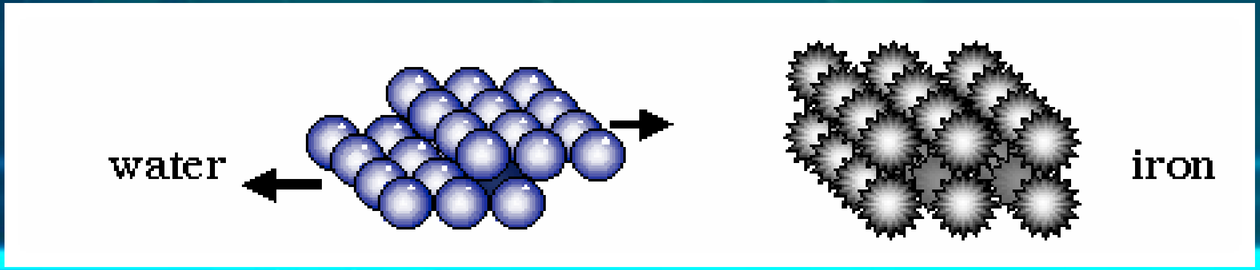
Democritis
(400 BCE)

- First to propose idea of atom
- Atom = “a” + “tomos” = cannot be cut
- Based solely on logic; not supported by experiments

Democritus (c. 460 BC

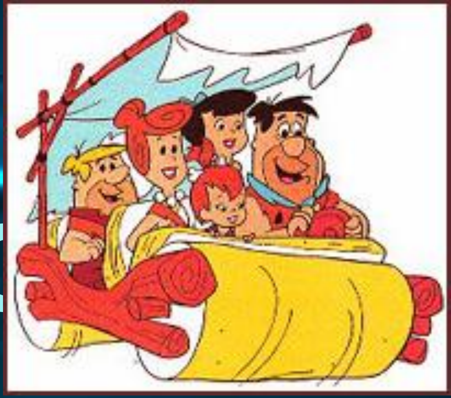
- Democritus asked: If you keep breaking matter in half, how many breaks will you have to make before you can't break it apart any further?
- Democritus called the smallest possible bits of matter atoms. (indivisible in Greek)
- He had

theory.



Democritus was supposedly known as 'the laughing philosopher' because of his wry amusement at human foibles.

The Ancients – B.C



- Believed Aristotle's theory that everything was made up of the fundamental "elements"
  - Earth
  - Wind (air)
  - Fire
  - Water

Aristotle's Folly

- Unfortunately Aristotle *(the more popular Greek philosopher)* dismissed the atomic idea of Democritus as worthless. *(What?!)*
- For more than 2000 years nobody did anything to continue Democritus' work.
- No surprise, we call these the "Dark Ages" of atomic theory.

Alchemy (12-1500 CE)

- recognized importance of experimentation
- Responsible for developing lab equipment & procedures still used today

NOTE: Alchemy is a field, NOT a person…

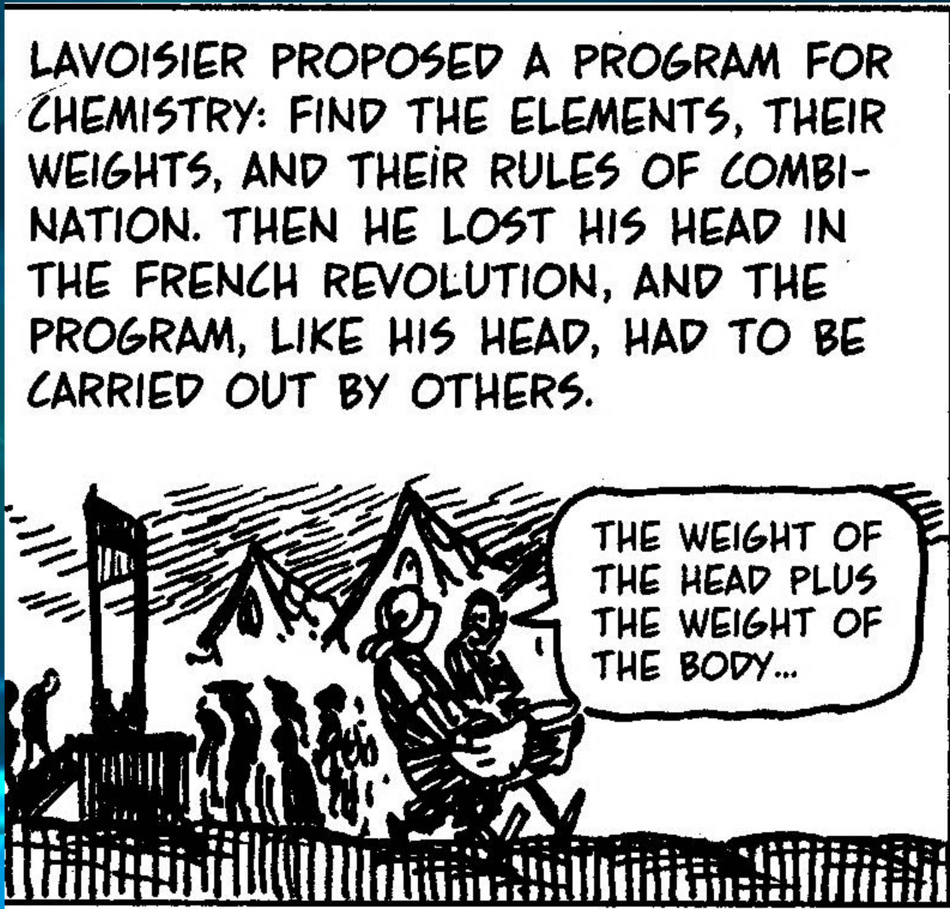
Galileo (~1600 CE)

- Birth of modern science - combining logic, experimenting, publishing results
- Modern word ‘chemistry’ came from Arabic ‘alkimiya’

Lavosier & Priestly (1700's)

- Quantitative analysis of chemicals

Law of Conservation of Mass:
Matter can neither be created nor destroyed



Proust
(1700’s)

– Developed Law of Definite Proportions

Law of Definite Proportions: Different samples of the same compound always contain its constituent elements in the same proportions by mass

Law of Definite Proportions

- Copper carbonate always contains
  - 5.3 parts copper
  - 4 parts oxygen
  - 1 part carbon

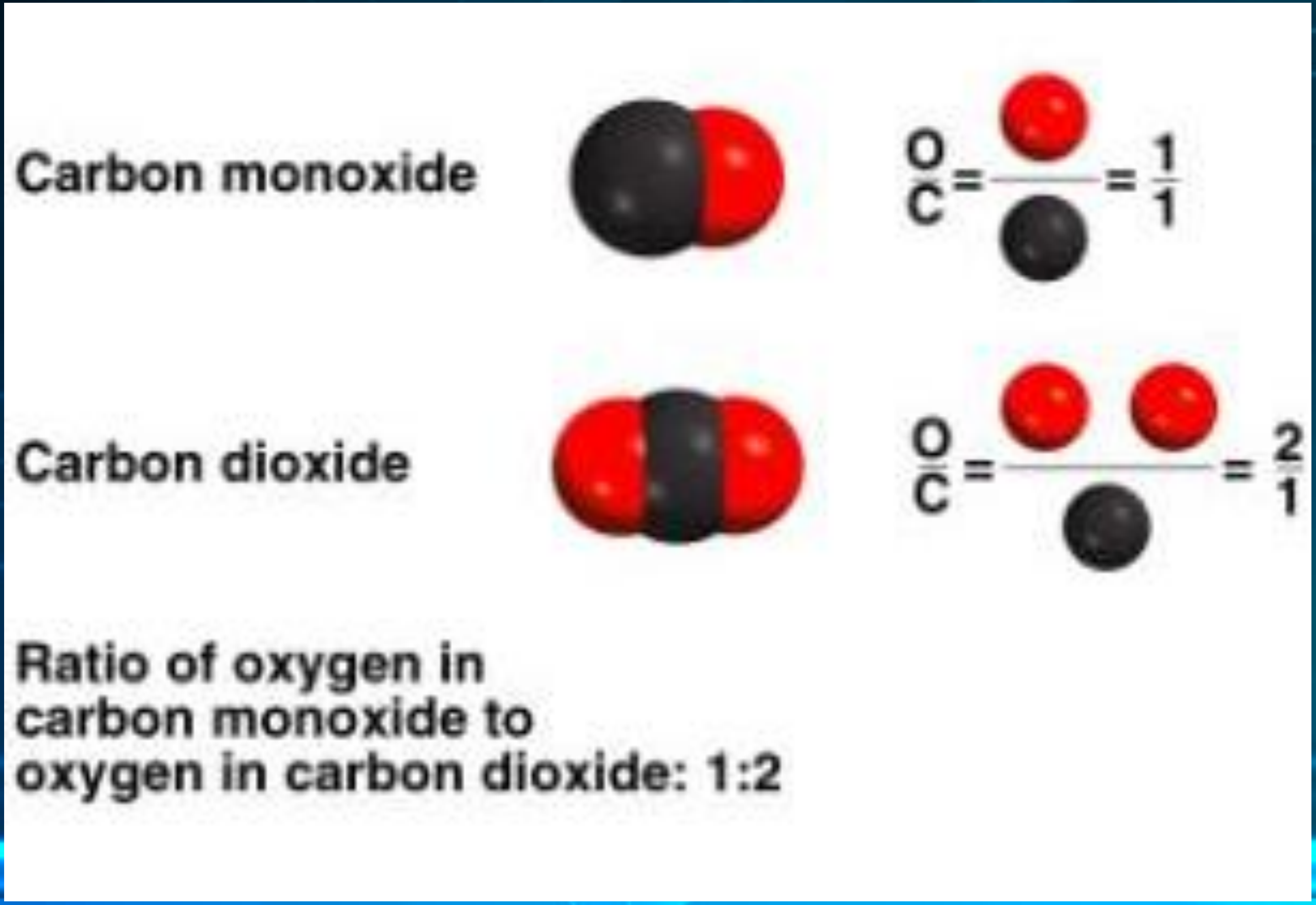
  by mass

Dalton (1800's)

- School teacher that proposed the first modern-day idea of atoms

Law of Multiple Proportions:
If 2 elements combine to form more than one compound, the masses of one element that combine with a fixed mass of the other element are in small whole # ratios

Law of Multiple Proportions



Dalton's Atomic Theory - 1808

- All matter is composed of atoms which cannot be subdivided
- Atoms of same element are identical (size, mass, reactivity)
- Atoms combine to form compounds in simple, whole # ratios
- Chemical reactions involve the separation, combination, or rearrangement of atoms; it does not result in their creation or destruction

Dalton's Concept

- **John Dalton proposed** the following **ideas about matter**:

1. matter is made up of atoms

2. atoms cannot be divided into smaller pieces

3. all the atoms of an element are exactly alike

4. different elements are made of different kinds of atoms

- Dalton pictured an atom as a hard sphere that was the same throughout.

Scientific Evidence

- In **1870, William Crookes did experiments with a glass tube** that had almost all the air removed from it.
- The glass tube had two pieces of metal called electrodes sealed inside.
- The electrodes were connected to a battery by wires.

A Strange Shadow

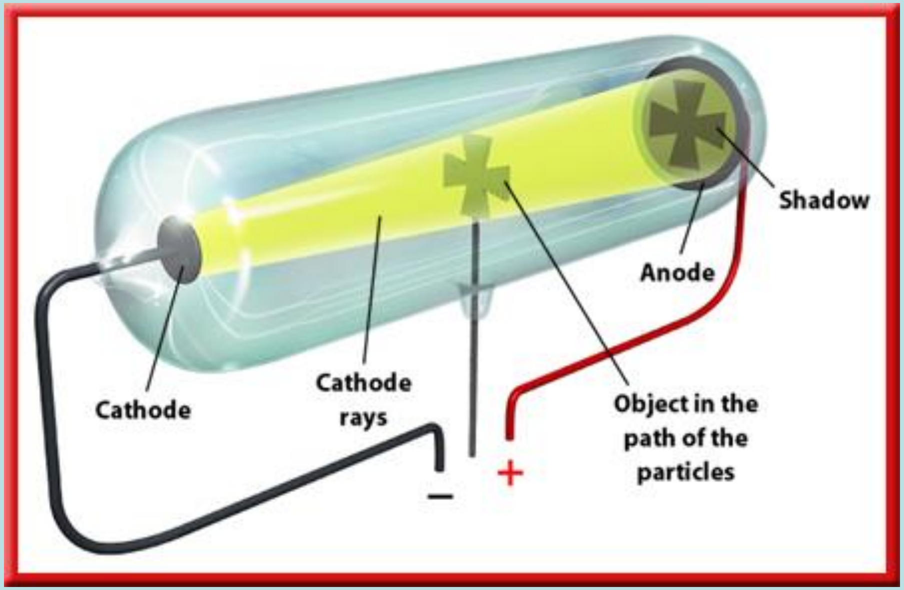
- When the battery was connected, the glass tube suddenly lit up with a greenish-colored glow.

- A shadow of the object appeared at the opposite end of the tube—the anode.

A Strange Shadow

- The shadow showed Crookes that something was traveling in a straight line from the cathode to the anode, similar to the beam of a flashlight.

- The cross-shaped object was getting in the way of the beam and blocking it.



Cathode Rays

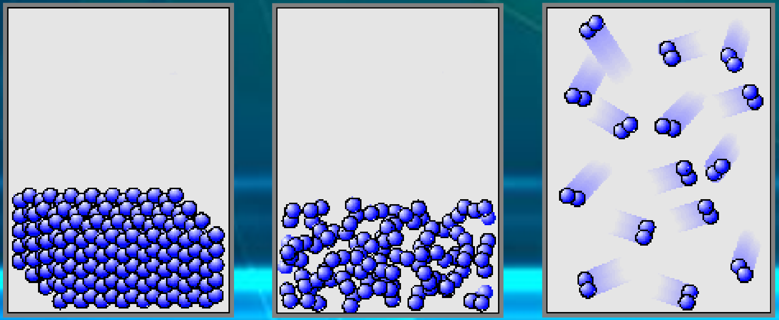
- **Crookes hypothesized that the green glow in the tube was caused by rays, or streams of particles**.
- These **rays were called cathode rays because they were produced at the cathode**.
- **Crookes' tube is known as a cathode-ray tube**.

Characteristics of Gases

Gases expand to fill any container.
- random motion, no attraction

Gases are fluids (like liquids).
- no attraction

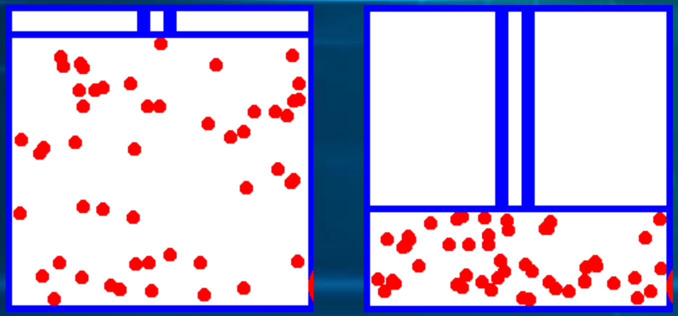
Gases have very low densities.
- no volume = lots of empty space

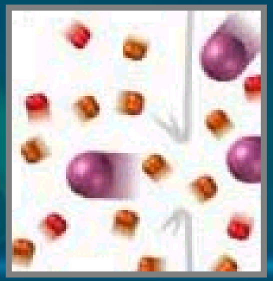


Courtesy Christy Johannesson www.nisd.net/communicationsarts/pages/chem

Characteristics of Gases

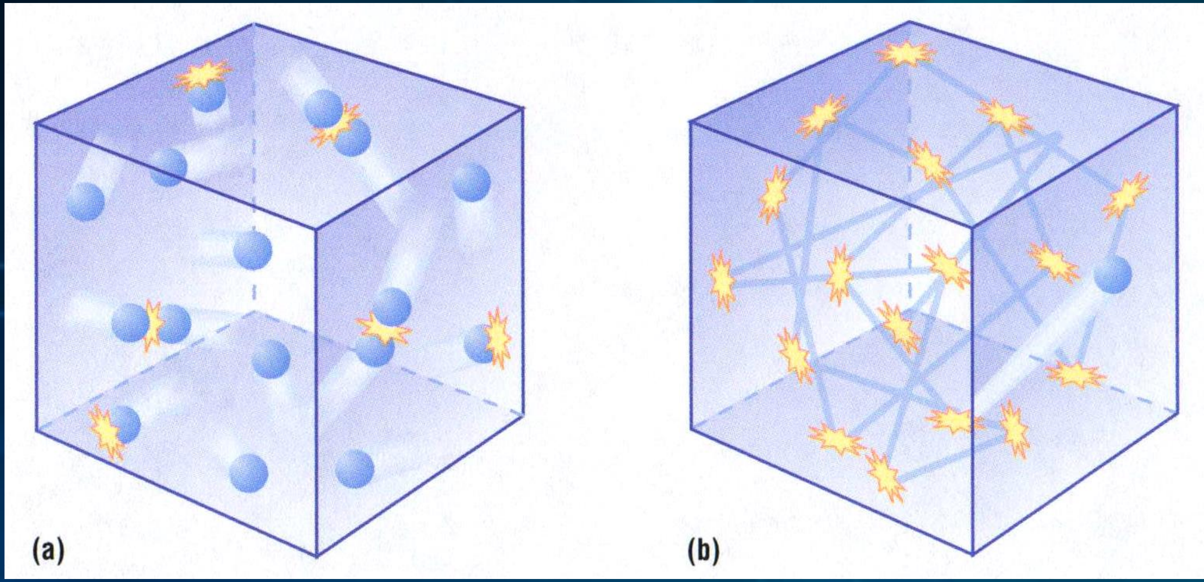
- **Gases can be compressed.**
  – *no volume = lots of empty space*
- **Gases undergo diffusion & effusion.**
  – *random motion*

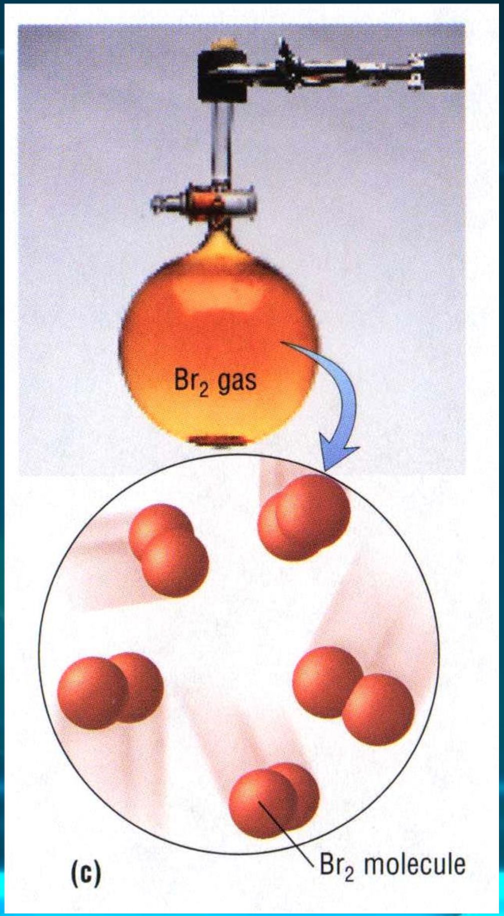




Collisions of Gas Particles

Kinetic Theory

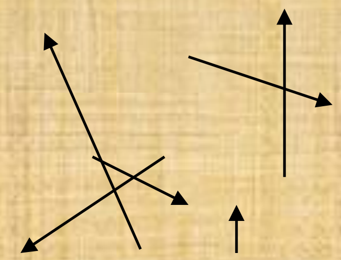




Kinetic Molecular Theory (KMT)

- explains why gases behave as they do
- deals w/“ideal” gas particles…

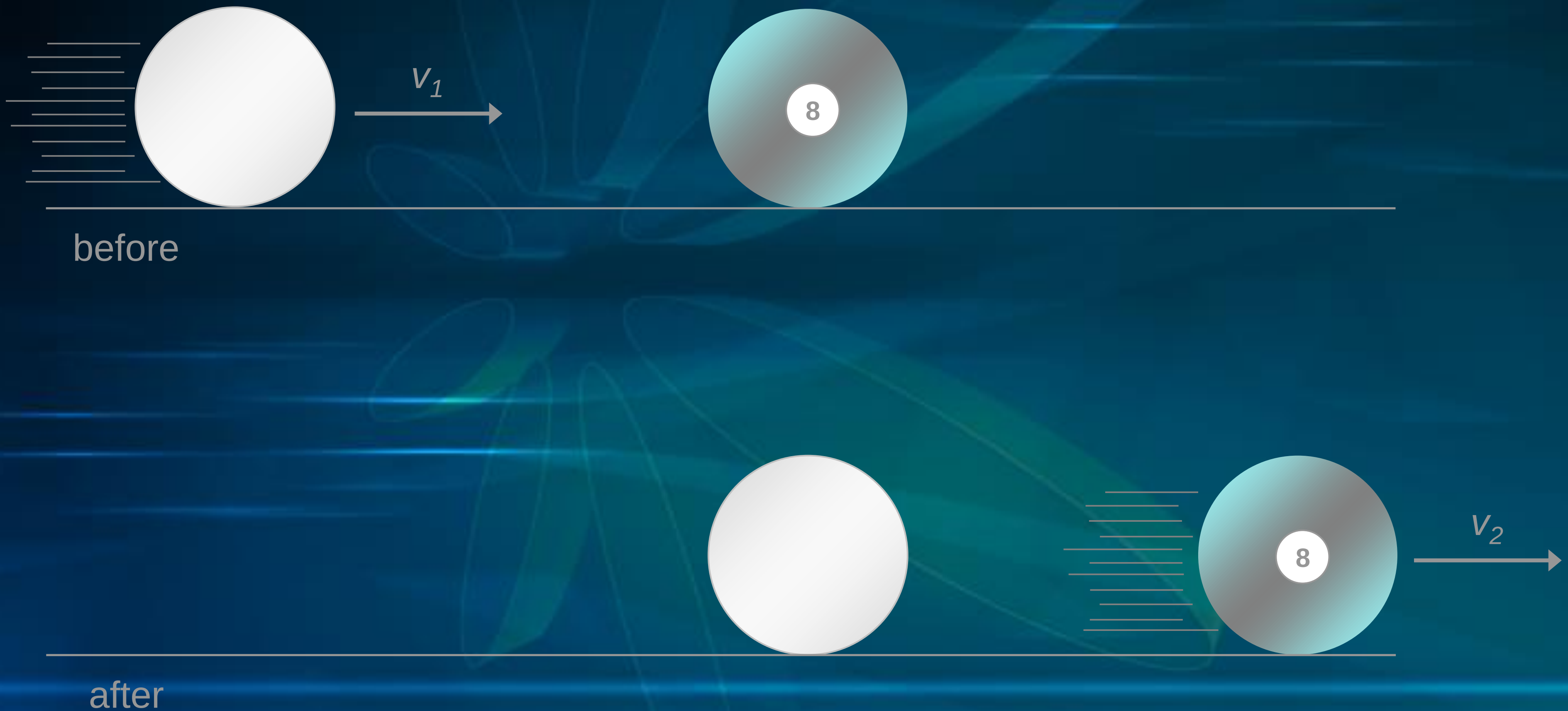
1. …are so small that they are assumed to have zero volume
2. …are in constant, straight-line motion



3. …experience elastic collisions in which no energy is lost
4. …have no attractive or repulsive forces toward each other
5. …have an average kinetic energy (KE) that is proportional to the absolute temp. of gas (i.e., Kelvin temp.)

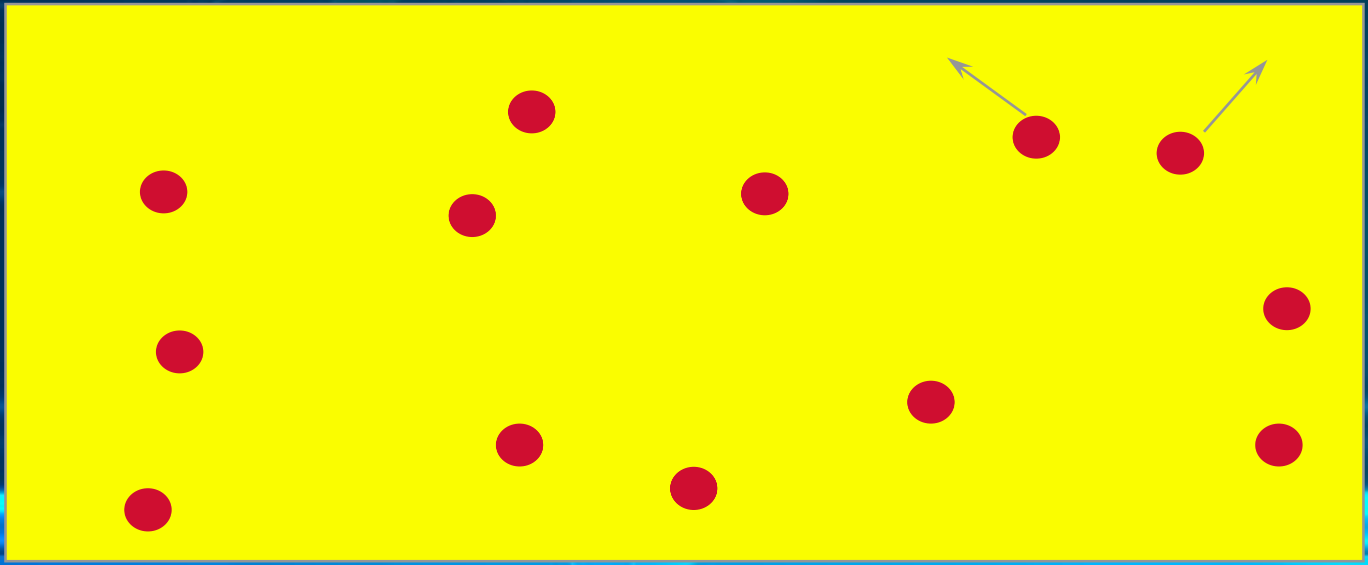
AS TEMP. ↑, KE ↑

Elastic Collision

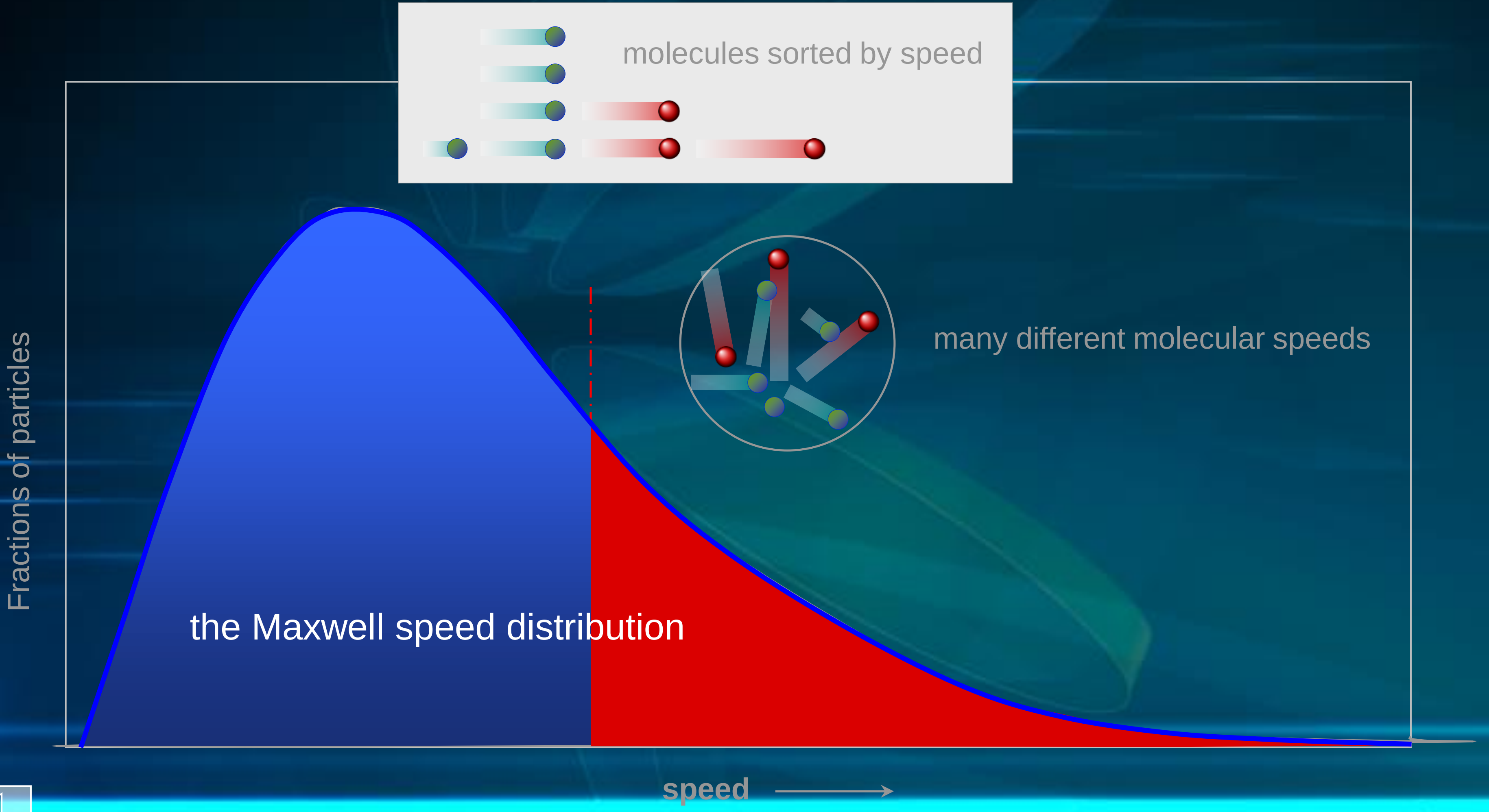


Kinetic Molecular Theory

- **Particles in an ideal gas…**
  - have no volume.
  - have elastic collisions.
  - are in constant, random, straight-line motion.
  - don’t attract or repel each other.
  - have an avg. KE directly related to Kelvin temperature.



Molecular Velocities



Properties of Gases

Gas properties can be modeled using math.
Model depends on:

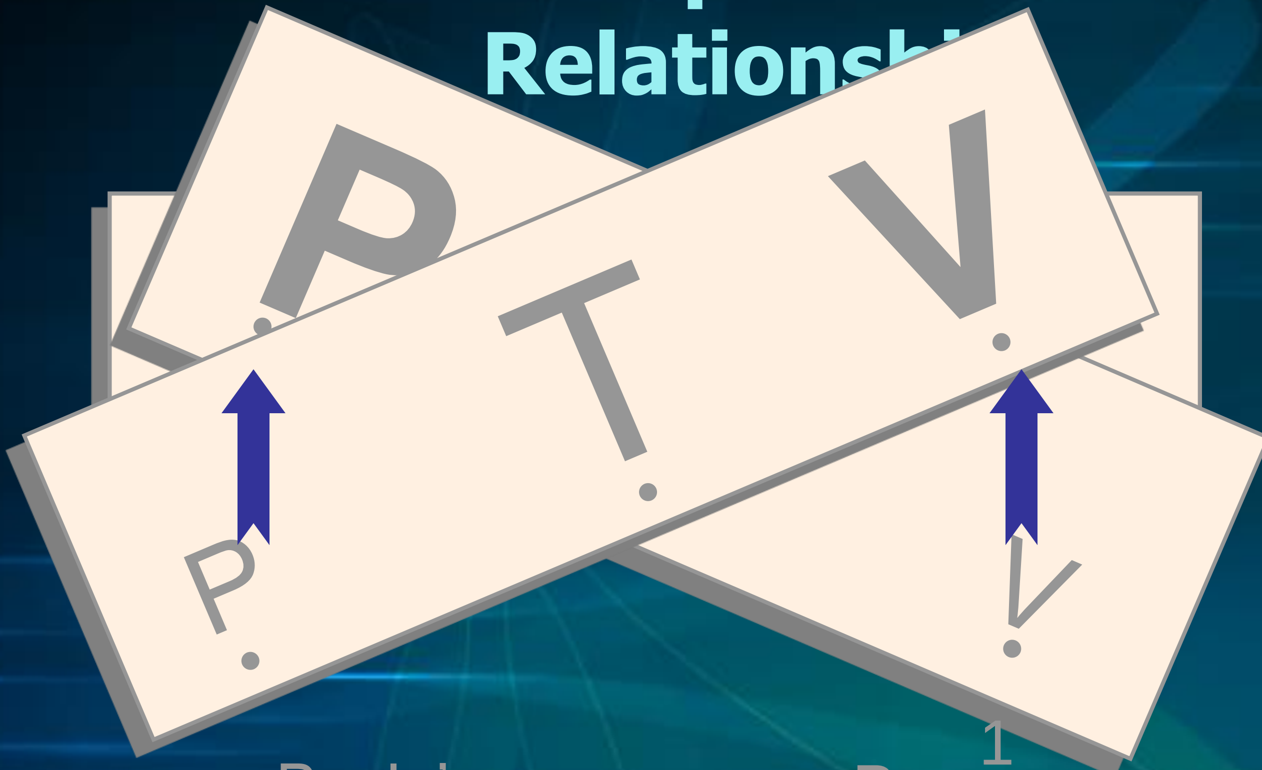
V = volume of the gas (liters, L)

T = temperature (Kelvin, K)

P = pressure (atmospheres, atm)

n = amount (moles, mol)

Pressure - Temperature - Volume Relationshi



Boyle's	$P \alpha \frac{1}{V}$
Charles	$V \alpha T$
Gay-Lussac's	$P \alpha T$