Atomic Theory and Chemical Reactions

SEPUP
Science in Global Issues
Chemistry: Fueling the World
Activity 12
Field Test (Spring, 2008)

John Dalton's Atomic Theory

Each element is made of a characteristic kind of atom.

- All the atoms of one element are identical to each other and different from atoms of other elements
- When elements react to form compounds, their atoms combine

Atoms are indivisible and very small

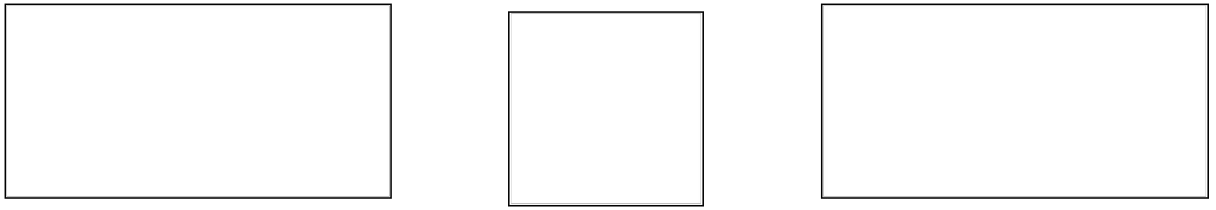
Dalton's model leads to this representation for the synthesis of water

Hydrogen + oxygen water

Gay Lussac's Observations

- The ratios of the volumes of gaseous reactants and products can always be expressed in whole number ratios
- For the synthesis of water:

  2 volumes hydrogen + 1 volume oxygen □ 2 volumes water



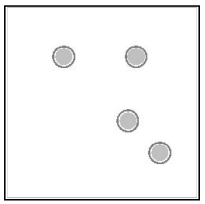
Gay Lussac's Observations

1a. What happens if you try to apply Dalton's model to explain Gay Lussac's observations?

Try it on your Student Sheet by using drawings like Dalton's. The oxygen is filled in for you.

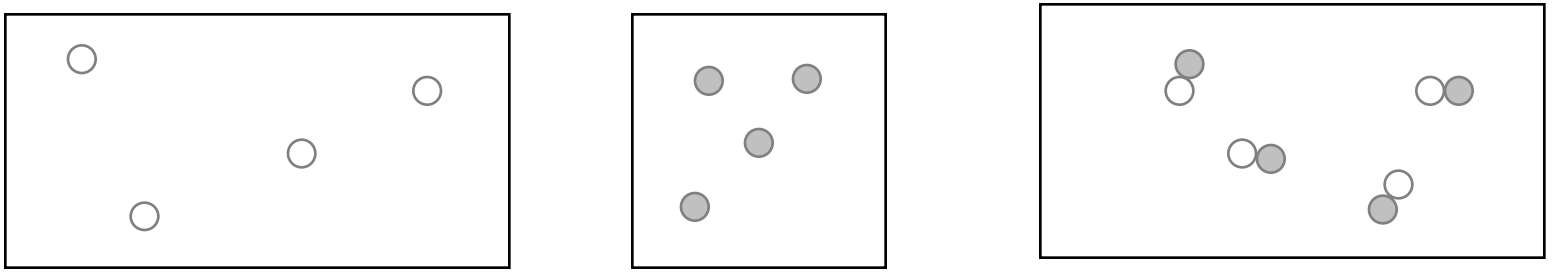
- For the synthesis of water:

  2 volumes hydrogen + 1 volume oxygen □ 2 volumes water



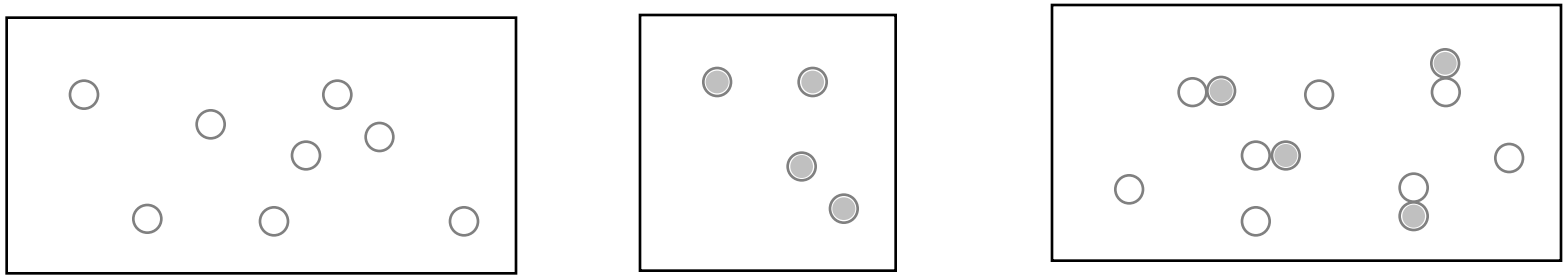
You might have tried. . .

2 volumes hydrogen + 1 volume oxygen □ 2 volumes water



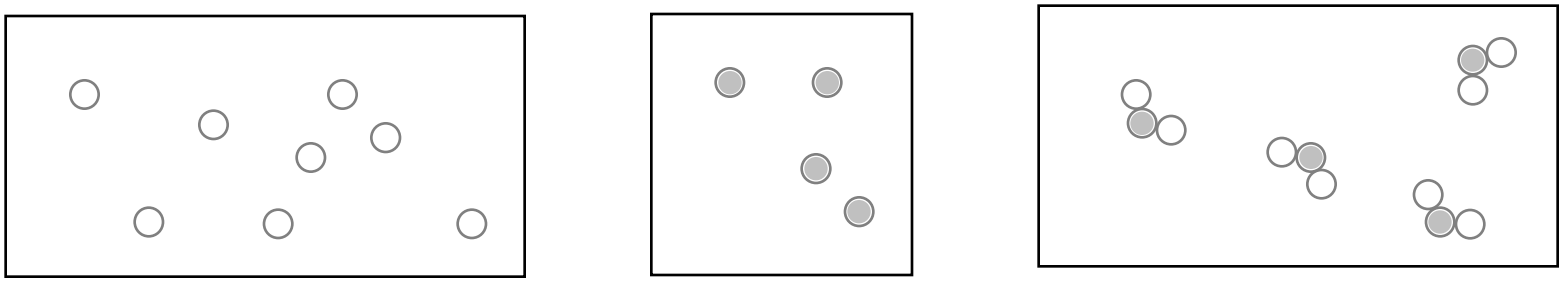
This follows Dalton's model, but does not explain the different volumes of hydrogen, oxygen, and water vapor formed.

Or, you might have tried. . .



This follows Dalton's model, but leaves left over hydrogen, which is not what Gay-Lussac observed in his experiments. Does it explain the volume differences?

You might even have tried. . .



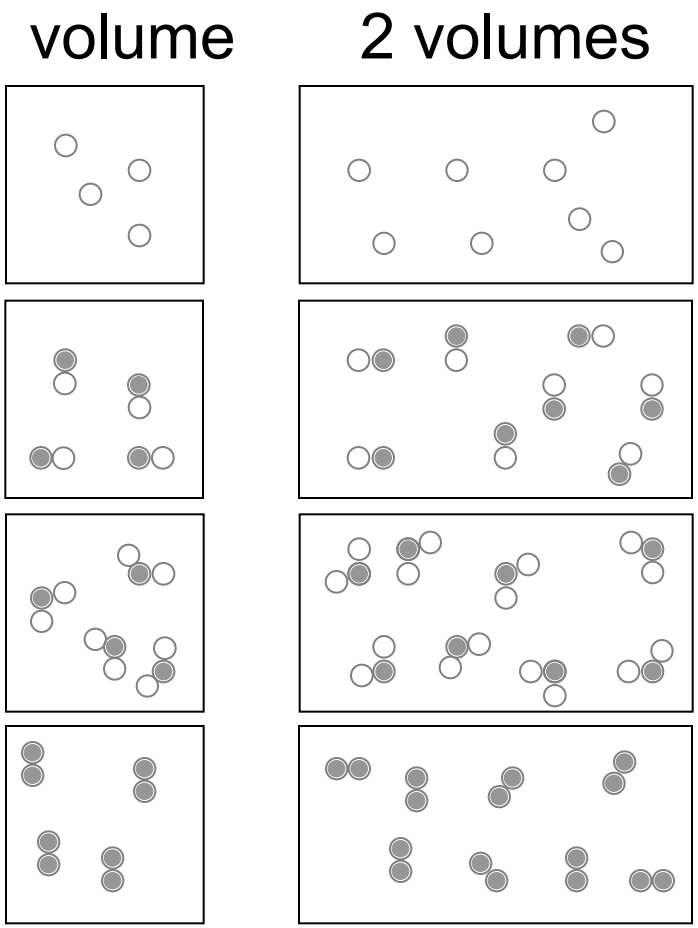
This adds to Dalton's model the idea that water's formula is H_2O. Does it explain the different volumes?

Gay-Lussac's Law

- Gay-Lussac's observations were confirmed in many reactions of gases
- Now called:
  - The Law of Combining Volumes of Gases
- This law cannot be explained by Dalton's representations.
- How was the discrepancy resolved?

Avogadro's Hypothesis

- Equal volumes of gases have equal numbers of particles
- These particles may be atoms or molecules



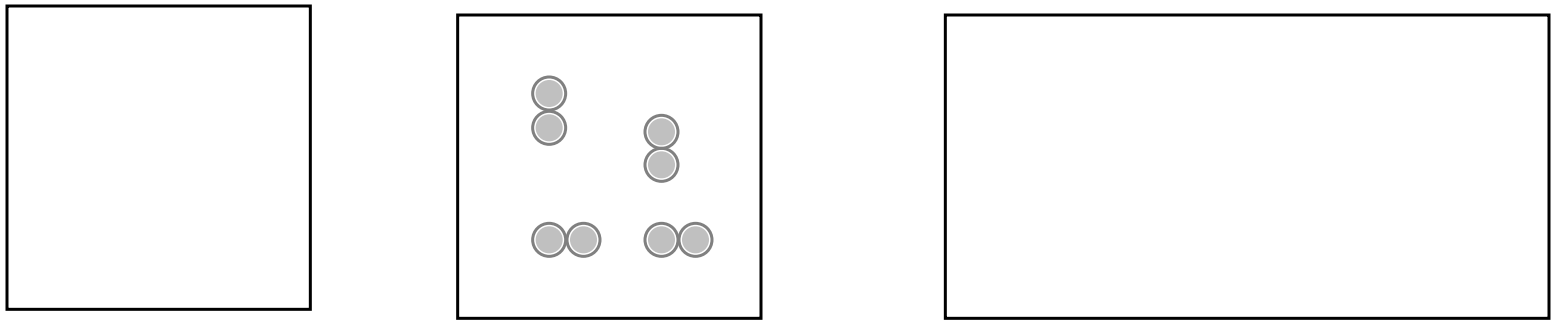
Avogadro's other idea: some elements might be made of diatomic molecules, as in the example to the right.

Avogadro's Hypothesis

- Equal volumes of gases have equal numbers of particles.
- Gaseous elements such as hydrogen, nitrogen, oxygen, and chlorine are diatomic.

2a. Draw the particles predicted by Avogadro in the boxes below. The chlorine particles are filled in to get you started. Does it work to explain the volume results?

1 volume hydrogen + 1 volume chlorine □ 2 volumes hydrogen chloride



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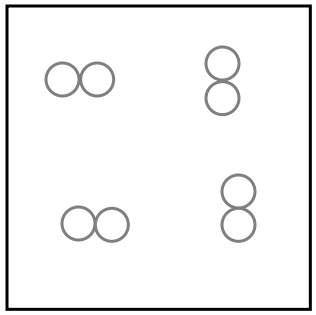

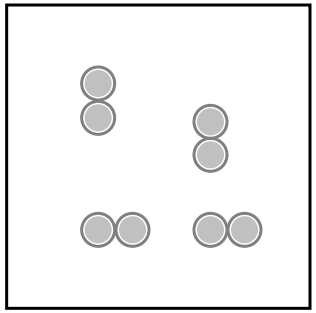

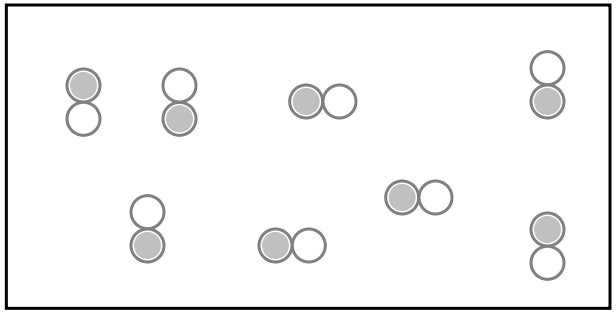

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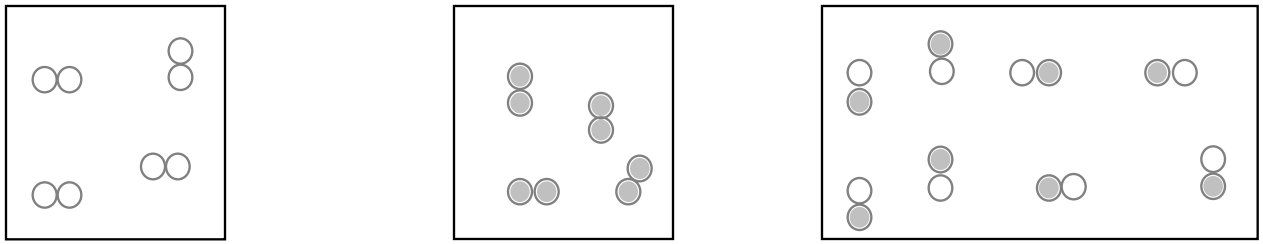


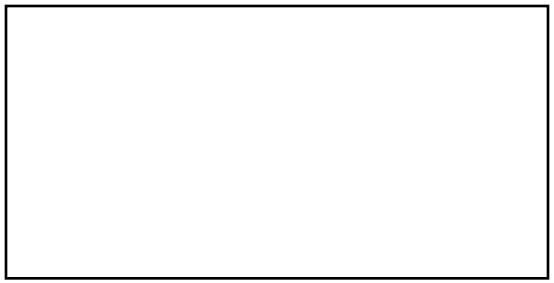
$2\ H_2$ + Cl_2 □ $2\ HCl$

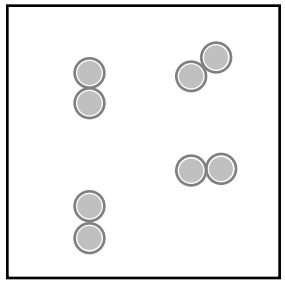
Avogadro's Hypothesis

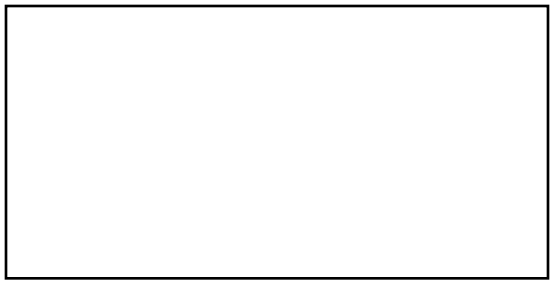
3a. Now try both of Avogadro's ideas on the water example you tried earlier. Remember, Avogadro proposed that:

- Equal volumes of gases have equal numbers of particles.
- Some elements are diatomic. The examples you will see in this activity are hydrogen, oxygen, chlorine, and nitrogen.

2 volumes hydrogen + 1 volume oxygen □ 2 volumes water





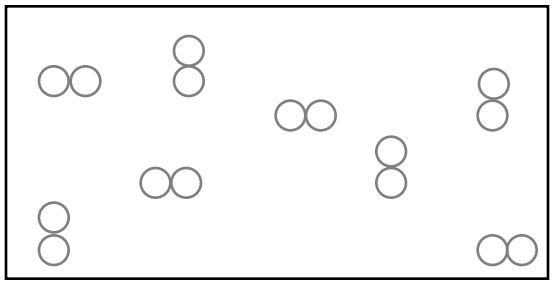


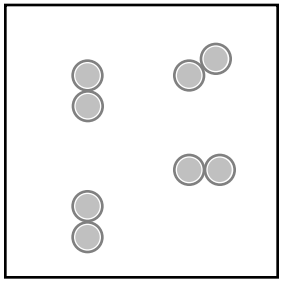
Avogadro's Hypothesis

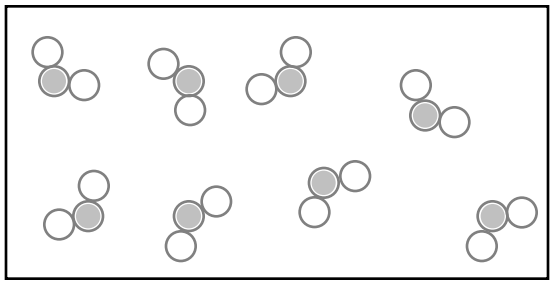
3a. Now try both of Avogadro's ideas on the water example you tried earlier.

- Equal volumes of gases have equal numbers of particles
- Gaseous elements such as hydrogen, nitrogen, oxygen, and chlorine are diatomic.

2 volumes hydrogen + 1 volume oxygen □ 2 volumes water







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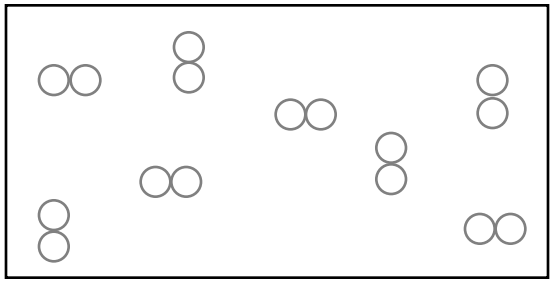
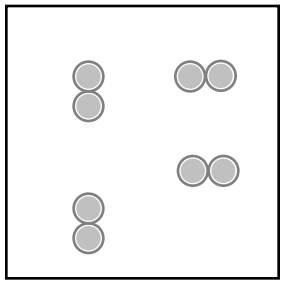
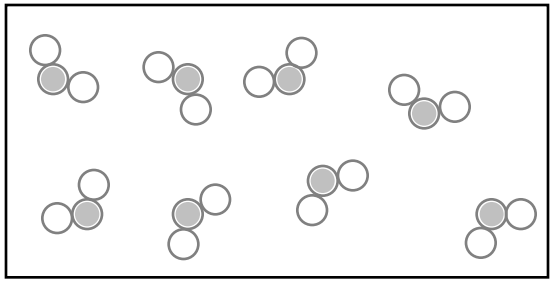


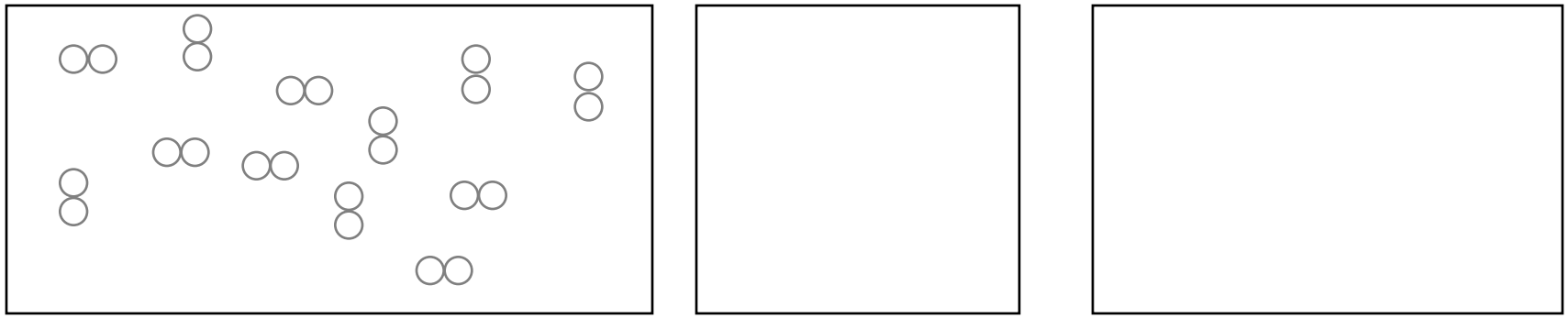




$2\,H_2$ + O_2 □ $2\,H_2O$

Now try the synthesis of ammonia

4a. 3 volumes hydrogen + 1 volume nitrogen □ 2 volumes ammonia



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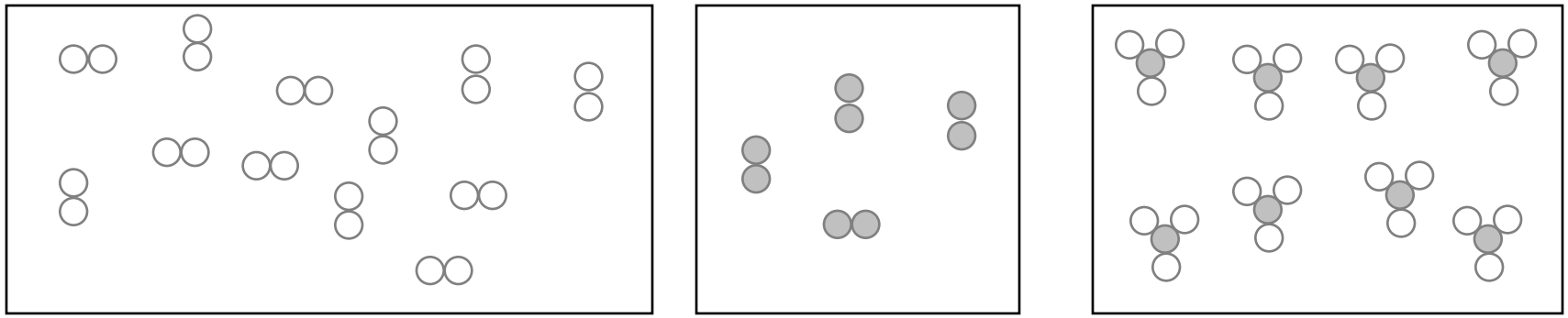

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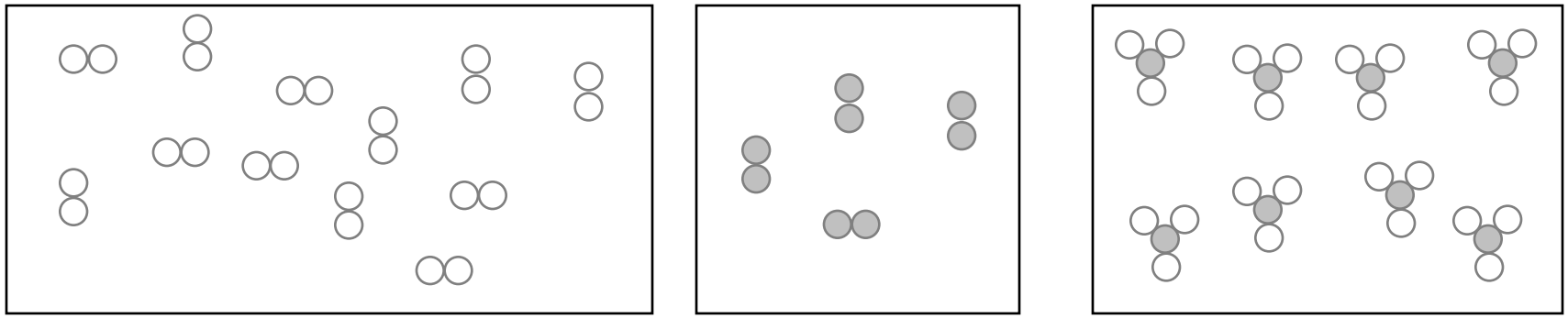

$3\ H_2 \quad + \quad N_2 \ \square \quad 2\ NH_3$

The Atomic Theory

- Based on Dalton's early ideas of atoms
- Modified based on later findings, such as Avogadro's Hypothesis