

## Lesson plan using *Friction, States of Matter* and *Gas Properties* as demonstrations for reviewing Kinetic Molecular Theory and particle nature of matter

This activity replaces one that used Microwaves in Jan of 09, I plan to use it at the first of the year as part of Chapter 1, description of matter.

**Learning Goals:** Students will be able to describe matter in terms of molecular motion. The description should include

- **Diagrams to support the description.**
- **How the particle mass and temperature affect the image.**
- **What are the differences and similarities between solid, liquid and gas particle motion**
- **How the size and speed of gas molecules relate to everyday objects**

Background:

I plan to use this lesson to review or introduce KMT. For students who have had physics, this will be a review, for others it may be the first time they have heard of KMT. If this is the first exposure, the idea is just to get the students thinking about the particle nature of matter and later in the year, I will use the KMT activity <https://phet.colorado.edu/en/contributions/view/2816> for them to develop a more deep understanding.

KMT summary:

1. Matter is made up of particles having negligible mass are in constant random motion (vibrate, rotate, translate)
2. The particles are separated by great distances
3. The particles collide perfectly elastically (there are no forces acting except during the collision)
4. The temperature of a substance is related to the molecular velocity.

Sim use hints:

Using *Friction*: Gently rub the two layers together so that the students can see the rise in temp and the increase in molecular motion. If you rub too vigorously or have the layers too close together, the molecules have so much energy that they leave the surface. This is probably distracting.

Lesson: I made a slide show to go with this; a teacher could follow the slide show or the directions below.

**Have *Friction, States of Matter* and *Gas Properties* all running before class starts**

1. First, have the students rub their hands together, then write down and illustrate what they think is happening on a molecular level. **Slide 3**
  - a. Then project the *Friction* sim and gently rub the two layers together so that the students can see the rise in temp and the increase in molecular motion.
  - b. Have a class discussion on how their image and description match the simulation images. We will have a class discussion about how we could show the various motions of particles. *Most of my students draw vectors off round balls.*
2. At the same temperature are the molecules all going the same speed? *Gas Properties* shows this well.

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3. Next, have the students draw models for gas, liquid and solid on their paper. Project the *States of Matter* sim. Toggle around to show different phases and effects of temperature. Point out rotational, translational, and vibrational motion Use for vibration demonstration  
<http://chemeddl.org/collections/molecules/index.php>
  - How could material be the same temperature and yet have different Phase?  
*Average molecular speed is related to mass and bonding. They may not think of the bonding yet. They should remember  $KE=1/2mv^2$  and remember that KE is directly related to temperature. The *Gas Properties* sim illustrates that different mass has different speeds. You might discuss bonding, but I waited until the bonding chapters.*
4. Project *Gas Properties* to get molecular size and speed. Have the students write a sentence that relates size and speed to real things.
  - a. Say: “Write on your paper: a molecule travels \_\_\_ as fast as a car. Show your calculations.” I’ll remind them that 60 mph is about 26m/s *440 m/s is about the average heavy species at the default settings, so about 20 times. This is a good time to remind students that air is mostly nitrogen*
  - b. I decided to make this just a quick question without the students calculating Write on your paper:, “\_\_\_ water molecules are in a raindrop(.5 cm). *The molecules are about .1nm, so .5E-2/.1E-9 is 5E7 or 50 million.*