Kinetic Energy Demonstration

Kinetic Molecular Theory and PTV

FLINN SCIENTIFIC CHEM FAX!

Introduction

Small pieces of metal shot and BBs are good models for the kinetic-molecular theory of matter and the properties of gases.

Concepts

- Kinetic-molecular theory
- Kinetic energy

Materials

BBs, large or other sphere

BBs, small or other sphere

Overhead projector or chemcam

Petri dish or other clear lidded container

Safety Precautions

Although the materials used in this demonstration are considered nonhazardous, please follow all laboratory safety guidelines. Wash hands thoroughly with soap and water before leaving the laboratory.

Preparation

1. Place several of each size BB into a Petri dish.
2. With the lid on the Petri dish move the dish back and forth on an overhead projector or project the image with a chemcam.

Disposal

The materials used in this activity are reusable.

Tips

- Practice using the device on an overhead projector before demonstrating with it to the class. With a little practice you will become adept at shaking the apparatus to illustrate key ideas while keeping the BBs in focus on the overhead. Use the demonstrator with various lessons during different times of the year to illustrate the nature of matter and molecular motion.
- The Molecular Motion Demonstrator, AP6466, may be used to demonstrate solid, liquid, and gas molecular movements. Please consult your *Flinn Scientific Catalog/Reference Manual* for further information regarding this item.

Discussion

The best model for explaining the behavior of gases is called the kinetic-molecular theory (KMT). There are two assumptions in this model: 1) the average kinetic energy of a gas depends on temperature and 2) the volume of the gas particles is extremely small compared to the volume the gas occupies—most of the volume of gas is “empty space.” The kinetic–molecular theory may be summarized in one simple phrase—molecules in motion. This activity provides a visual demonstration of this important concept. Visualizing molecules in motion helps students understand and compare the kinetic and potential energy of molecules in the solid, liquid, and gas phases. This model can be used to explain on a molecular level what happens when a solid melts or a liquid boils and also to predict the energy changes that accompany these phase changes.

The energy changes that occur when a solid melts or a liquid freezes can best be understood by imagining what solids and liquids look like at the level of molecules or ions. Solids and liquids differ in how ordered or rigid their structures are and in the range of motion that the molecules are allowed. Molecules in a crystalline solid are packed together in an ordered three dimensional pattern, called the crystal lattice, where they are "held in place" by attractive forces between the molecules. The motion of molecules in the solid state is limited to vibrations (stretching and rocking motions)—the molecules are not free to move away from their fixed positions. The forces between molecules in the liquid state are less well understood. Molecules in the liquid state are free to move and are not locked in position. Attractive forces between molecules, however, tend to keep the molecules close together, so that their motion is perhaps best described as coordinated rather than independent.

A solid and its liquid are in equilibrium at the melting point, the temperature at which a crystalline solid becomes a liquid. When a solid is heated (energy is added), the temperature of the solid will increase until it reaches the melting point. Temperature is related to the average kinetic energy of the molecules. As the temperature increases, the average kinetic energy increases and the molecules in the solid state begin to vibrate more rapidly. At the melting point, the vibrations become so rapid that the molecules begin to "break free" from their fixed positions and melting occurs.

The properties of liquids also reflect the motion of molecules in the liquid phase and the existence of attractive forces between molecules. According to the kinetic–molecular theory, the molecules in a liquid are in constant, random motion. The molecules are close enough together, however, that attractive forces between neighboring molecules influence their motion and give liquids their characteristic properties. Comparing the properties of different liquids allows us to compare the strength of attractive forces between molecules. The vapor pressure of a liquid reflects the ability of molecules in the liquid phase to break the attractive forces between them and "escape" into the vapor phase. Liquids with weak attractive forces between molecules have high vapor pressures are considered volatile—they will evaporate readily from an open container at room temperature. The kinetic–molecular theory also explains how the vapor pressure of a liquid increases as the temperature increases. Increasing the temperature increases the average kinetic energy of the molecules. At higher temperatures, a larger number of molecules will be moving fast enough and have sufficient kinetic energy to overcome the forces of attraction in the liquid and enter the vapor phase. The number of molecules in the vapor phase above the liquid, and hence the vapor pressure, increases with increasing temperature.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
- Systems, order, and organization
- Evidence, models, and explanation

Content Standards: Grades 5–8
- Content Standard B: Physical Science, properties and changes of properties in matter, motions and forces, transfer of energy

Content Standards: Grades 9–12
- Content Standard B: Physical Science, structure and properties of matter, motions and forces, conservation of energy and increase in disorder, interactions of energy and matter

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Kinetic Energy Demonstration* activity, presented by DeWayne Leineman is available in *Kinetic Molecular Theory and PTV*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Kinetic Energy Demonstration* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP6466	Molecular Motion Demonstrator
AB8170	Petri dish, Disposable, 100 5 15, Pkg. of 20

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.