Mole Element Sample Set

MOL-505

The Mole Element Sample Set contains four element specimens: iron, copper, zinc, and aluminum. Each sample has been sized to contain one mole of one element.

One mole of an element contains 6.02 x 10^{23} atoms, or:

602,000,000,000,000,000,000,000 atoms.

If you look up an element's atomic mass and "weigh out" that number of grams of the substance, you will have 6.02 x 10^{23} atoms of that element, also termed a **mole**.

Chemistry students doing mole-related calculations may have difficulty picturing the quantities involved in this concept. This set can help make the idea of a mole easier to visualize.

Of course, these samples may also be employed for a variety of more ordinary uses, such as density specimens, specific heat specimens, examples of common elements, etc.

Educational Innovations Inc. TEACHERS Serving TEACHERS!® 203-748-3224

Home | About Us | Lesson Ideas | Visit Us On Facebook | Contact Us | Shop Now

The Law of Dulong and Petit

by: Dr. Jean Oostens

Atoms were proposed in antiquity without any experimental evidence by Democritus, a Philosopher. This must have been a problem for Newton and Leibnitz who posited that there was always a mean of considering smaller and smaller intervals of space to calculate the "instantaneous velocity".

The introduction of the precision balance in chemistry by Lavoisier paved the way for Dalton to formulate his laws on the "definite and multiple proportions" governing chemical reactions. This supported the atomic theory, without giving it general acceptance.

Specific heat was defined as the quantity of heat needed to increase one gram of a substance by one degree. There was no definite pattern when specific heats of various substances were compared. Until two French scientists in 1819 calculated specific heat by atomic mass, forming the Law of Dulong and Petit. There appeared a number of cases where the results were quite similar: about 6 calorie per mole. This was equivalent to stating that any atom is as good as any other to store heat! This was a small step towards acceptance of the existence of atoms. An explanation for this, and the reason for the exceptions, had to wait the early 20th century explanation by Albert Einstein. By that time, atoms had gained wide acceptance from the work of Rutherford, and soon by Bohr.

Lesson on the Law of Dulong and Petit:

You are given several chunks of metal, each containing 0.6 * 10^{24} atoms (i.e. one mole) of one element. How will each of those samples, when dropped in a standard quantity of hot water (typically 200 mL and 70 C) affect the temperature?

Step 1. Use a good balance (at least 0.1 gm resolution) to determine which element you are dealing with. If possible confirm your identification with an additional cue.

The Law of Dulong and Petit

In addition to assorted lesson ideas on the next page, we have included a Specific Heat Experiment on page 3.* If you are seeking other ideas related to the Dulong-Petit Law, you may want to check out our blog:

http://blog.teachersource.com/2011/09/03/the-law-of-dulong-and-petit/

*** Additional lessons and experiments are included in the six-page manual that accompanies this set.**

Lesson Ideas

- Each metallic element comes as an unmarked bar. Have your students identify each sample. The mole samples can be identified by mass, density, ferromagnetism, or even color.

- Instruct your students to observe the relative sizes of the metals. Since each bar is 1.0 mole and therefore contains 6.0×10^{23} atoms, what does that say about the size of the atoms themselves? Is one type of atom larger than another? Since each sample contains the same number of atoms, this does indeed mean that aluminum atoms are larger than copper atoms.

- Have your students calculate the mass of one atom! Weigh a sample, and then divide by the number of atoms in that sample, 6.0×10^{23}. Since each sample weighs a different amount, the atoms in that sample weigh different amounts. For example, a copper atom is heavier than an aluminum atom.

- Calculate the volume of one atom! Multiple the length, width, and height of one of our samples, then divide by 6.0×10^{23}, which will result in the volume of one atom.

- Dividing the mass of one atom by the volume of one atom will result in the density of a single atom.

- Compare the densities of copper and aluminum. Aluminum is less dense than copper, which explains why a copper atom can both weigh more and take up less space than an aluminum atom. Have your students compare and contrast the different properties of the samples.

Specific Heat Experiment

The purpose of this experiment is to determine the molar specific heat of the elements aluminum, copper, iron, and zinc.

Procedure:

1. Tie a piece of string tightly around each of the four samples. Heat the samples in boiling water to a constant temperature of 100°C.

2. Prepare four styrofoam cups to act as calorimeters. Each cup should be filled with cool water, but no ice. Record the mass of water in the cup. Place a thermometer in the cup and record the temperature of the water.

3. Quickly remove one metal sample from the boiling water and place it in a calorimeter. Gently raise and lower the metal to ensure that heat is transferred to the water uniformly, but do not remove the sample from the water. Record the temperature of the water every 30 seconds until a maximum temperature is reached.

Calculations:

The amount of heat absorbed by the water will equal the amount of heat released from the metal sample. The amount of heat absorbed by the water can be calculated using the formula

$$\mathbf{Q = nC_M\Delta T}$$

where **Q** is the heat absorbed, **n** is the number of moles of water present, $\mathbf{C_M}$ is the molar specific heat of water (75.3 $^{J}/_{(mol)(°C)}$), and **ΔT** equals the final temperature of the water minus the initial temperature of the water.

Once the heat absorbed by the water has been calculated, the specific heat of the metal can be calculated using the same formula, where $\mathbf{C_M}$ is the only unknown variable. (Hint: there is one mole of the sample, and the final temperature of the sample will be the same as the final temperature of the water). The accepted values for the molar specific heats of the samples are:

Al: 24.3 $^{J}/_{(mol)(°C)}$
Cu: 24.5 $^{J}/_{(mol)(°C)}$
Fe: 25.3 $^{J}/_{(mol)(°C)}$
Zn: 25.2 $^{J}/_{(mol)(°C)}$

While the specific heats of each metal measured in $^{J}/_{(g)(°C)}$ differ, the specific heats measured in $^{J}/_{(mol)(°C)}$ approach 25 $^{J}/_{(mol)(°C)}$.

For a discussion of why these values are so similar, have your students research the Law of Dulong and Petit. Enjoy!

Take Your Lesson Further

As science teachers ourselves, we know how much effort goes into preparing lessons.
For us, "*Teachers Serving Teachers*" isn't just a slogan—it's our promise to you!

Please visit our website for more lesson ideas:

TeacherSource.com/lessons

Check our blog for classroom-tested teaching plans on dozens of topics:

http://blog.TeacherSource.com

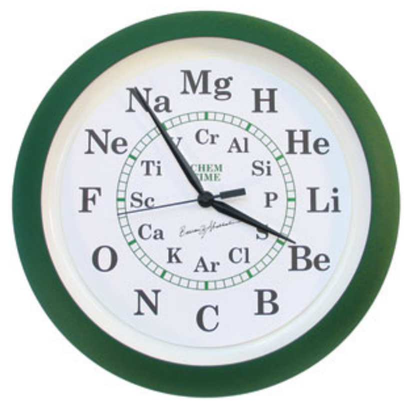
To extend your lesson, consider these Educational Innovations products:

Density Cubes (DEN-220)

Students identify each metal cube by determining its density. This classic lab is now available with extra large (easy-to-measure) 2.5 cm cubes of six different metals. Each set includes one cube each: aluminum, brass, copper, iron, lead, and zinc. Plus, students can use the density of the samples to calculate the purity!

Chem Time Clock (TIM-510)

Our 24-hour Chem Time Clock replaces the usual numbers found on the face of a clock with symbols of elements having corresponding atomic numbers. 'H' replaces 1, 'He' replaces 2, etc. The idea for this clock came from Prof. Bassam Shakhashiri at the University of Wisconsin, who had one made during the summer of 1983. It is the perfect addition to a science classroom.



Goldenrod Color-Changing Paper (SM-925)

True goldenrod paper is made from a dye which is an acid-base indicator. This paper turns bright red in bases such as ammonia, baking soda, or washing soda and returns to bright yellow in acids such as vinegar or lemon juice. Make your own indicator paper or use to preserve fingerprints. Instructions included. Color-changing goldenrod paper has become very difficult to find. Ours is guaranteed to be color changing.