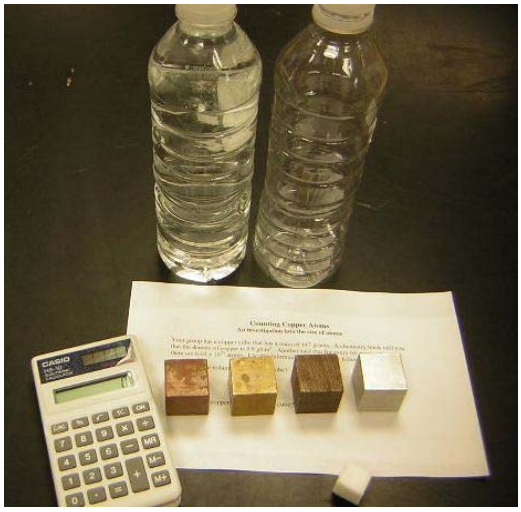
Teacher Notes- "Counting Atoms-An Investigation Into The Size Of Atoms"



How in the world can you measure something that's so small that it's never been seen, and probably never will be?

In this challenging but fun activity students will count the number of atoms in a metal cube not with their eyes, but with math. When done, they will fully appreciate just how small atoms are.

Materials (per group of 4 students):
1-density block set (item #WW46065M00 at sciencekit.com)
4-calculators
4-Student Handouts (see last page)

Additional Materials: (all optional)
PowerPoint- "Two Minute Timer.ppt" (see last page), or a watch
1-empty and 1 full water bottle (optional)
1-sugar cube (optional)

Beforehand:

1. Decide which kind of metal block to use:
    a. Ideally, you already have 8 sets of density blocks, enough to allow you to give each group of 4 students the same kind of metal block (so there's only 1 kind of block being used in the classroom). That would create the easiest situation for you to manage, since everyone would be using copper or brass. If you don't have any density blocks and have the means, go ahead pick up as many sets as you need. You'll find other uses for them besides this activity (they're also used in the Interactive Notes for Electricity).

    b. If you only have 2 sets of blocks, that will still work. You would then need to use all of the metal blocks from both sets, giving you 8 total (2 copper, 2 aluminum, 2 brass, and 2 steel). The student handout has been done for all 4 kinds. Just make sure students get the handout that matches their kind of block.

    c. If you don't have the time or money to buy Density Blocks, look around your room or the plumbing department of your local hardware store. Iron, copper, brass, and aluminum are everywhere. All that's really needed is a sample for your students to touch, which gives meaning to the numbers. If you have any brass weights or aluminum foil, that will also do the trick.

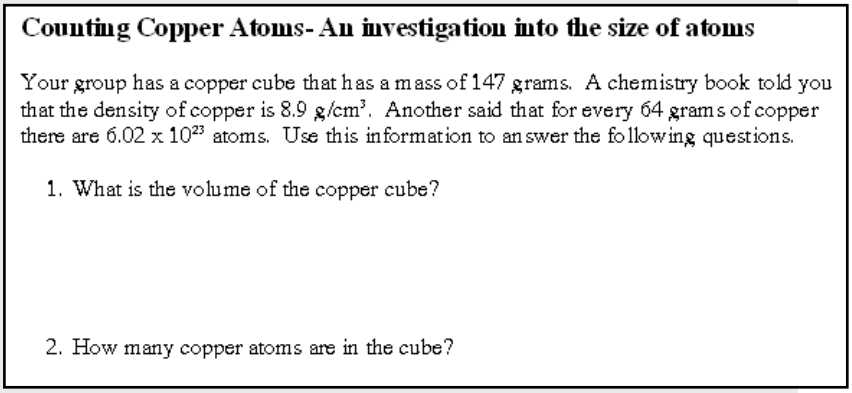
2. Copy and cut handouts for the kind of blocks you're using.

3. Set out all materials the day before. Leave yourself time to realize you're missing something, research something or even make a change. You'll also need to sit down with a blank sheet of paper and do all the math yourself so you know what your students are about to experience.

Procedure:

1. Begin by reading the paragraph on the student handout aloud in class *one sentence at a time* with student readers. Pause after every sentence to do some out-loud thinking. Don't hurry- an ordinary class will get through this activity in about 35 minutes. Here's a sample discussion, referring to a copper cube:

(sentence 1 of the handout reads: "Your group has a copper cube that has a mass of 147 grams.") Say- "Pass the cube around and hold it in your hand, thinking 'this is what 147 grams feels like. Remember that number- we'll need it later. Let's read the next sentence.



Counting Copper Atoms- An investigation into the size of atoms

Your group has a copper cube that has a mass of 147 grams. A chemistry book told you that the density of copper is 8.9 g/cm^3. Another said that for every 64 grams of copper there are 6.02 x 10^{23} atoms. Use this information to answer the following questions.

1. What is the volume of the copper cube?

2. How many copper atoms are in the cube?

(then read sentence 2) A cm^3 is a space that is 1 cm long x 1 cm wide x 1 cm long (*hold up the sugar cube*)… about like this. If your copper cube was as big as this sugar cube it would weigh (pause and allow students to say the answer first) 8.9 grams! Is your cube 1cm x 1cm x 1 cm? (no- it's bigger)
How much does it weigh again? (147 grams)
Ah, it weighs more than 8.9 grams because it's larger than 1 x 1 x 1, right? (right).
Let's read the next sentence.

(sentence 3) And further, if your cube weighed exactly 64 grams, which we know it doesn't, how many copper atoms would it have? (6.02 x 10^{23}).
Good! For those of you with good memories, I want you to note that this number is called Avogadro's number. You'll need this number again in a few years when you're in chemistry class. But that's not really important right now.

Now, look at the decimal point in that number, 6.02. Imagine it moved over 23 places to the right. That's how many atoms of copper would be in there if your cube weighed 64 grams. But does it? (no).
No sirree. It weighs….remind me again… look again at sentence 1… (147 grams). Let's get to work."

2. Before students have a chance to get too worked up over the mathematics, tell them that this activity is for bonus points only and that they're working together in small groups. That takes all the pressure off of them, so they can now relax and maybe get something out of this. Students who aren't usually successful in math may now take a "nothing to lose" approach and actually try.

3. Lastly, and this is for your sake, have each group choose just 1 handout to represent their group and put all their names on it. They will all still do the work on their own handout, but only one paper gets turned in per group. That reduces your grading by ¾ .

Question One

4. Read question number 1 aloud with the class- **What is the volume of the cube?**

5. On the chalkboard write the equation ***D = M / V*** . Have everyone write it down in the space below the question. Write the word *density* near the D. Ask:

> "What does 'density' mean? (Take 3-4 responses).
>
> (*Hold up the two water bottles, one empty and one full.)*
> Ok everyone, I'm now going to ask you a TRICK QUESTION. Get ready. A TRICK QUESTION is one where you do not answer with your first impulse, no matter what it is. Are you ready to be TRICKED? -Which bottle takes up more space? (neither- the bottles are identical).
> Good answer. Which is heavier? (the one with water).
> We can say the one with water is more dense because it has more 'stuff' in the same amount of space. That's all 'density' means.
> Gold is extremely heavy. It is more dense than wood or plastic for the same reason- more stuff (protons, neutrons, and electrons) in the same amount of space.
>
> Back to the question, here's the good news- we know what that *D* in the formula is because sentence #2 tells us copper's density. And the *M*, which stands for…. (mass) is also given! Do you remember what you told yourself the mass of your cube was when you held it in your hand? *(don't say the number out loud-let them remember)*
> So all you have to do is plug in the values for *D* and *M*, and the only thing left to do is solve for *V*, the volume. If you can solve that in 2 minutes, you'll earn 3 bonus points.
>
> I'll keep track of time on my computer screen (*using the "Two Minute Timer" or a clock).* If you haven't figured it out by the end of 2 minutes, I'll give another clue, and then we'll play for 2 bonus points. Begin!"

6. Start the 2 minute PowerPoint timer if you're using it. It will be big enough on your screen that you can turn it towards the class and not have to use a multimedia projector with a screen pulled over the chalkboard that you need today.

At the end of the countdown is an explosion sound. If you don't want it to play, you can turn down the volume on your computer or take the sound off the slide. To do that, click the "Slide Show" menu option at the top, then "Custom Animation", and click on slide #121. Click once on the animation (the number 0) and "Remove" it.

7. Award 3 bonus points to groups that succeed by getting the correct answer (16.5 g/cm^3 for copper) in less than 2 minutes. Either mark +3 on their group paper or have them put it there themselves. (all answers are on the last page of this document)

8. When the 2 minutes are up, give the following clue for groups who haven't got it yet:

> "Ok. I understand it's difficult to turn equations around, so for the first clue I'll help you with that. Write this down: V = M / D . *(Remind them again that the values of M and D are given in the handout.)* Solve it in the next 2 minutes and each person in your group will earn 2 bonus points. You may begin!"

9. Restart the timer by pressing the Esc button on your keyboard then F5 again.

10. Award 2 bonus points now for correct answers.

11. When 2 minutes are up write the number values of *M* (147 grams for copper) and *D* (8.9 g/cm^3) on the board over each other, which is all but solving it for them.

12. Restart the timer. Award 1 bonus point now. Everyone is now done with question 1.

Question Two

13. Read question number 2 aloud- **How many atoms are in the cube?**

14. On the board write the following proportion, shown below in blue. To get them started, talk out loud to yourself as you write the following so students understand where the numbers came from. Assuming again the numbers for copper:

$$\frac{64}{6.02 \times 10^{23}} =$$

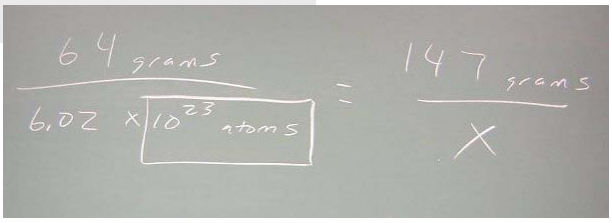
"Let's see… the handout said for every…**64** grams of copper, there are… how many atoms?…**6.02×10^{23}** atoms. OK.

Class, I know what you're thinking and I agree with you- those are scary numbers. But each means something important. Stop and think- every 64 grams of copper has 6.02×10^{23} atoms. Small, aren't they? Proportions set a scale for comparison. Now onto the right side of the equation- how much does your cube weigh? (147 grams)

$$\frac{64}{6.02 \times 10^{23}} = \frac{147}{}$$

In math, how do you say 'I don't know?' (x)

$$\frac{64}{6.02 \times 10^{23}} = \frac{147}{x}$$



So, we're solving for x. Very good. One last thing before you begin- draw a little box around the 10^{23} exponent. Now it's in jail. Ignore it for now and run the rest of your numbers as if it wasn't there. When you get an answer, let him out and stick him on the end of it. You may begin!"

15. Start the 2 minute timer and award 3 points to groups that succeed.

16. When the 2 minutes are up, give the following clue for groups who haven't got it yet

"The first step in solving a proportion is…. (*wait for student help*) cross-multiplying. Good. Let's cross-multiply then, and if we keep ignoring the exponent like I said, we end up with

64X = 884.94 (*put on board*)

Now solve for X in 2 minutes for 2 bonus points. Go!"

17. Restart the timer. Award 2 bonus points now for correct answers.

18. When the 2 minutes are up, write on the board:

$$X = \frac{884.94}{64}$$

19. Restart the timer. Award 1 bonus point now. Everyone is now done with question 2. The answer, by the way, for the copper cube is 13.8×10^{23}, which is the same as 1.4×10^{24}. That's exactly how many atoms there are in it, assuming it weighs 147 grams and it's pure copper.

Conclusion:

20. Hopefully, students are excited about atoms and even mathematics. But in the excitement the whole idea of how small atoms are may have been lost. So begin tomorrow with a student volunteer writing 13.8×10^{23} on the board. Have another write it out long ways, literally moving the decimal 23 times to the right.

21. Don't forget to erase the chalkboard with all the answers on it in between classes.

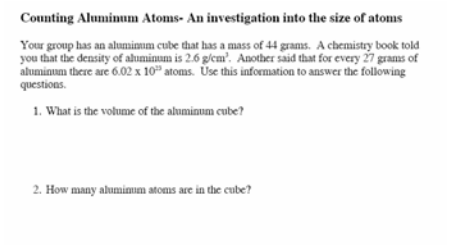
Answers:

	Question 1 *(g/ cm^3)*	Question 2 *(atoms)*
Copper	16.5	13.8×10^{23} $=1.4 \times 10^{24}$
Aluminum	16.9	9.8×10^{23}
Brass	16.2	6.5×10^{23}
Steel	16.2	13.5×10^{23} $=1.4 \times 10^{24}$

Come back and visit InteractiveScienceTeacher.com to upgrade this lesson with:

PowerPoint- (2 minute timer)

Student Handout



Counting Aluminum Atoms- An investigation into the size of atoms

Your group has an aluminum cube that has a mass of 44 grams. A chemistry book told you that the density of aluminum is 2.6 g/cm^3. Another said that for every 27 grams of aluminum there are 6.02×10^{23} atoms. Use this information to answer the following questions.

1. What is the volume of the aluminum cube?

2. How many aluminum atoms are in the cube?

*Quick*Notes

Teacher *Quick* Notes- "Counting Atoms- An Investigation Into The Nanoworld Of Atoms"

Materials (per group of 4 students):
1-density block set
4-calculators
4-student handouts (included in *Resources* folder)

Additional Materials: (all optional)
PowerPoint- "Two Minute Timer.ppt" (included in *Resources* folder), or other timer
1-empty and 1 full water bottle
1-sugar cube

Procedure:
1. Read the handout aloud in class one sentence at a time with student readers. Pause after every sentence to do some out loud thinking.
2. Before students have a chance to get too worked up over the impending mathematics, tell them that this activity is for bonus points only and that they're working together in small groups.
3. Lastly, before diving in, have each group choose 1 paper from among them to represent their group and put all their names on it.

Question One
4. Read question number 1 aloud- **What is the volume of the cube?**
5. On the board write the equation $D = M / V$. Have everyone copy it down below the question. Write the word *density* near the D.
6. Start the 2 minute timer. Award 3 bonus points to groups that succeed. Mark +3 on their group paper.
7. When the 2 minutes are up, turn the equation around for groups who haven't got it yet.
8. Restart timer. Award 2 bonus points now for correct answers.
9. When 2 minutes are up, write the number values of *M* and *D* on the board.
10. Restart timer. Award 1 bonus point now. Everyone is now done with question 1.

Question Two
11. Read question number 2 aloud- **How many atoms are in the cube?**
12. On the board write (assuming copper):