

Allotropes: What does structure have to do with it?

A collection of activities investigating allotropes for  
High School Chemistry Classes

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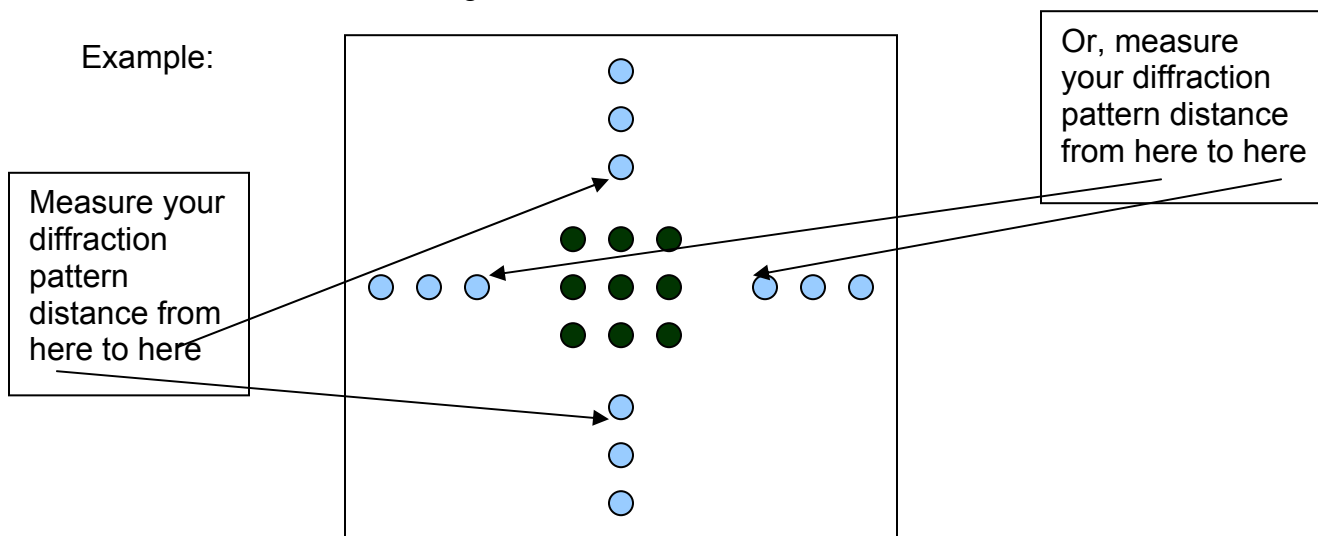
Regents Chemistry  
Determining Relationships in Diffraction

Name:

When a wave encounters an obstacle, some of the wave bends or diffracts around that obstacle. You are being asked to determine the relationship between the size of your obstacle and the amount of diffraction that is occurring. Your wave source will be a red laser pointer since those waves will all be the same size, and your projection screen will be a 3x5 card that is 1 meter away from your light. The only variable will be your obstacle, in this case a piece of mesh screening. Your diffraction pattern will change in response to your screen size.

The diffraction pattern produced by the wire mesh on the index card will look like the mesh in the center, with dimmer lines extending both above and below, as well as to the left and the right.

Example:



**Caution: Never point a laser beam at someone's eye or look directly into it yourself!**

**Procedure:**

1. Tape your 3x5 card to a wood block or the wall, place your penlight 1 meter away.
2. Test the penlight by turning it on, you should see a single spot on your card. Be sure the spot is relatively close to center.
3. Obtain the largest mesh screen, meaning the wires are the farthest apart. Place the screen in front of the light, turn the laser on and observe your pattern. Measure the diffraction and record in the table below.
4. Repeat for the medium and small pieces of wire mesh, recording all data in the table.

**Results:**

Wire Mesh Size	Diffraction distance in mm
Large	
Medium	
Small	

**Conclusions:**

As the size of the mesh **decreases** (or, there are more lines, smaller holes) the distance the light diffracts \_\_\_\_\_ (increases, decreases or remains the same)

This is known as a/an \_\_\_\_\_ (inverse or direct) relationship.

**Extensions:**

For the advanced student or the student who has already had physics.

Using the diffraction equation, find your distance between the wires in the mesh.

$$w = \frac{L \cdot \lambda}{d}$$

w = pattern spacing on your screen (from diffraction spot to another, you must cut your number from the results section in half, or better yet repeat your measurements)

L = distance to screen (1 meter for our lab)

d = size of object (your unknown)

$\lambda$  = wavelength of your red laser = 650nm

*Be sure all your units are converted to be the same!!*

Regents Chemistry  
Name:

Web quest  
Allotropes

You will be learning about allotropes of carbon and phosphorus as you answer the questions below by visiting the three web sites listed.

**First, find the wise geek site at <http://www.wisegeek.com/what-is-an-allotrope.htm>**

1. Define allotrope:
2. Why is an allotrope not just a different phase of the element? (example: liquid v. solid)
3. Do allotropes have the same configuration (grouping) of their atoms? Do they have the same physical and chemical properties?
4. What are the formulas for the two allotropes of oxygen, and which form is more abundant?
5. How many allotropes of carbon have been discovered so far?
6. Name some of the property variations that carbon atoms exhibit.

**Next, find the site with the movable models of allotropes at <http://science.marshall.edu/castella/chm212/chap22/c22pics.html>  
You must have the CHIME plug in for this site to work**

7. Starting with graphite, move the model around by left clicking on it and dragging with the mouse the direction you want it to rotate. Try all the directions until you get a feel for the arrangement of the atoms. Sketch pictures below from 3 different perspectives that best show the atomic relationships. One should show the “sheets” of carbon atoms, and another should show hexagons.

8. Click on and move the diamond around, rotating it many ways until you can see the geometry of it. Draw 3 different perspectives below, being sure to include one view showing the hexagonal arrangement.

9. Rotate the buckyball allotrope and notice how it is different from both graphite and diamond. Write a description of what you see below.

10. How many bonds does the carbon atom form with itself in graphite? \_\_\_\_\_ In a diamond and buckyball? \_\_\_\_\_  
Call Mrs. Frey over to explain why!

11. Skip to white and red phosphorus. How many bonds do each of the phosphorus atoms make with itself in both allotropes? \_\_\_\_\_  
Draw the lewis electron dot diagram of phosphorus and explain why it bonds this way.

12. Explain the main difference between how red and white phosphorus are bonded.

***Finally, find the site on “phosphorus, the 15<sup>th</sup> element” at the URL***  
***<http://www.chemicalforums.com/index.php?op=articles;id=16>***

13. Read the introduction paragraph over the three vials. Summarize that paragraph in your own words with one or two sentences.

14. What aspect of red phosphorus configuration makes it stable in air, yet able to react readily with most things?

15. How is red phosphorus useful in matches?

16. Name one physical and one chemical property of red phosphorus.

Physical =

Chemical =

17. Name one physical and one chemical property of black phosphorus.

Physical =

Chemical =

18. Phosphorus in Greek means “bearer of light”, how does that relate to the behavior of white phosphorus?

19. Warning – this question is not on the websites. Use your internal processor! Describe the difference between an allotrope and an isotope.

20. BONUS! Describe how Hennig Brandt discovered phosphorus. (the answer has a small “yuck” factor involved.)

Regents Chemistry  
Name:

## Lab – Building Carbon Allotropes (15)

**Problem:** Why is it that graphite and diamonds are both made from the same element in the solid phase yet exhibit such different properties?

**Hypothesis:(3)** Given what has been discussed in class, answer the question above. You may use your web quest or these websites as references if needed.  
<http://www.amnh.org/exhibitions/diamonds/electric.html>  
<http://science.marshall.edu/castella/chm212/chap22/c22pics.html>

### Procedure(6)

1. Find two molecular model sets and take them to your lab table.
2. As a lab table build two sheets of graphite using 15 atoms of carbon per sheet. Don't worry about the empty "holes" for bonding on the edges of your model.
3. Take a picture of your graphite using the digital camera provided and print your photograph.(3)
4. As a lab table, build a diamond using 30 atoms of carbon. Don't worry about the empty "holes" for bonding on the edges of your model.
5. Take a picture of your diamond using the digital camera provided and print your photograph.(3)

### Conclusion:(6)

1. Based on the atomic structures modeled, why would graphite conduct electricity while a diamond normally does not?(3)
2. Based on the atomic structures modeled, why do diamonds have a higher melting point than graphite?(3)

Write up: Each person is to write up the lab on separate paper with the problem, hypothesis, procedure and conclusions written. Collect your labs from the group and staple them together with your printed photos.

# Allotropes: Lesson Plan and Teacher Resources

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**Objective:**

SWBAT explain how crystal shapes and sizes are determined, and describe how elements allotropes differ for carbon and phosphorus.

The lesson will be in four parts, using 80 minutes of classroom time. Currently I do not plan to use a double minute lab period, rather I am planning on one class period for the first two activities, and another for the last two.

**Contents:**

- Discover the relationship between obstacle size and diffraction pattern through hands on experimentation. (Activity one – Determining Relationships in Diffraction)
- Power point lesson on diffraction and x-ray crystallography. (Activity two – Allotrope PowerPoint)
- Web quest to learn specific information on allotropes of carbon and phosphorus. (Activity three – Web Quest on Allotropes)
- Laboratory exercise on building models of two carbon allotropes, graphite and diamond. (Activity four – Building Carbon Allotropes Lab)

**Connections to NYS Regents Chemistry Core:**

***Key Idea*** - 5.2f

***Link to Appendix*** - II.6

***Major Understandings:*** Some elements exist as two or more forms in the same phase. These forms differ in their molecular or crystal structure, and hence in their properties.

***Real World Connections:*** Different properties for each allotrope

- Oxygen gas v. ozone
- Coal v. graphite v. diamond v. buckminsterfullerene

This activity will tie the term allotrope to a molecular modeling lab, and will help to reinforce the concept of different structures. It will not be performed during the periodic table unit, where elements are traditionally discussed. I envision this lesson will be performed at the end of the Bonding and Molecular Forces unit where students will have had experience building molecular models and can come away with a better understanding of covalent and network bonds.

## **Resources:**

The following internet sites were used in the development of these activities. All were in use as of August 2005.

<http://www.amnh.org/exhibitions/diamonds/composition.html>

<http://www.chemicalforums.com/index.php?op=articles;id=16>

<http://science.marshall.edu/castella/chm212/chap22/c22pics.html>

<http://science.marshall.edu/castella/C448.html>

<http://www.wisegeek.com/what-is-an-allotrope.htm>

<http://www.ccmr.cornell.edu/education/modules/>  
(Diffraction activity)

## **Materials Needed:**

Assumes lab groups of 3 – 4 students or pairs as indicated

Per laboratory group:

- Red laser pointer
- 3 sizes wire mesh (100x100 mesh/in; 200x200 mesh/in; 325 x 325 mesh/in) for each respectively d is approx 0.25mm; 0.125mm; 0.076mm. These screens were provided by CCMR and information for purchasing can be found at [www.mcmaster.com](http://www.mcmaster.com) or in the diffraction unit found on the CCMR education outreach website.
- 3x5 card taped to wood block as screen
- Tape
- Meter stick
- Ruler
- Dittos and PowerPoint presentation (paper copies for each student)
- Molecular model kit (2 or 3 per lab group – need 30 carbon atoms)

Per pair of students

- Internet access at a computer lab or laptop cart.
- CHIME® plug-in on the computers being used for the web quest. This is a free download from Molecular Design Limited. Found at <http://www.mdl.com/products/framework/chime/>

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