

# Atom Structure

## Teacher's Guide

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### 1.0 Summary

"Atomic structure" is the third activity to be done after the pre-test. This activity should take students approximately one class period.

### 2.0 Learning Goals

**Driving Question:** How do subatomic particles make an atom radioactive or ionic?

This activity provides an overview of the relationship between protons, neutrons and electrons in an atom. These particles combine in different quantities to make an atom radioactive or charged. Stable or non-radioactive atoms generally have about one proton for every neutron. Electrically neutral atoms have one electron for every proton.

#### Learning Goals

- Students will review the particles that make up an atom.
- Students will understand that the electron to proton ratio is 1:1 in electrically neutral atoms.
- Students will understand that stable atoms have about one neutron for every proton.
- Students will understand that radioactive atoms break down into different elements.
- Students will understand that radioactive elements give off energy when they break down.
- Students will learn to define a half-life.

#### Additional Teacher Background

Atoms are formed from protons, neutrons and electrons. Each of these particles contributes to the stability of an atom. The balance between protons and electrons contributes to the electrical stability of the atom. Atoms that are not electrically neutral tend to attract positive particles if they are negatively charged and negative particles if they are positively charged. This charged atoms are called ions and tend to be more reactive than neutral atoms. Since electrons have a negative charge, adding electrons makes the atom more negative. To calculate the charge on an atom use the following formula:

$$\text{Protons-Electrons} = \text{Charge}$$

Protons are held in the nucleus by the strong force. This is like superglue that holds the protons together. Normally they would break apart because of the like charges. Neutrons act as buffers against this repulsion. When there is about 1 neutron for every proton in the nucleus, the atom tends to be stable. If the atom has too few or too many neutrons the nucleus will break apart into a new atom. This breakdown of atoms is radioactivity. When this occurs you get smaller atoms and energy is released.

### 3.0 Standards Alignment

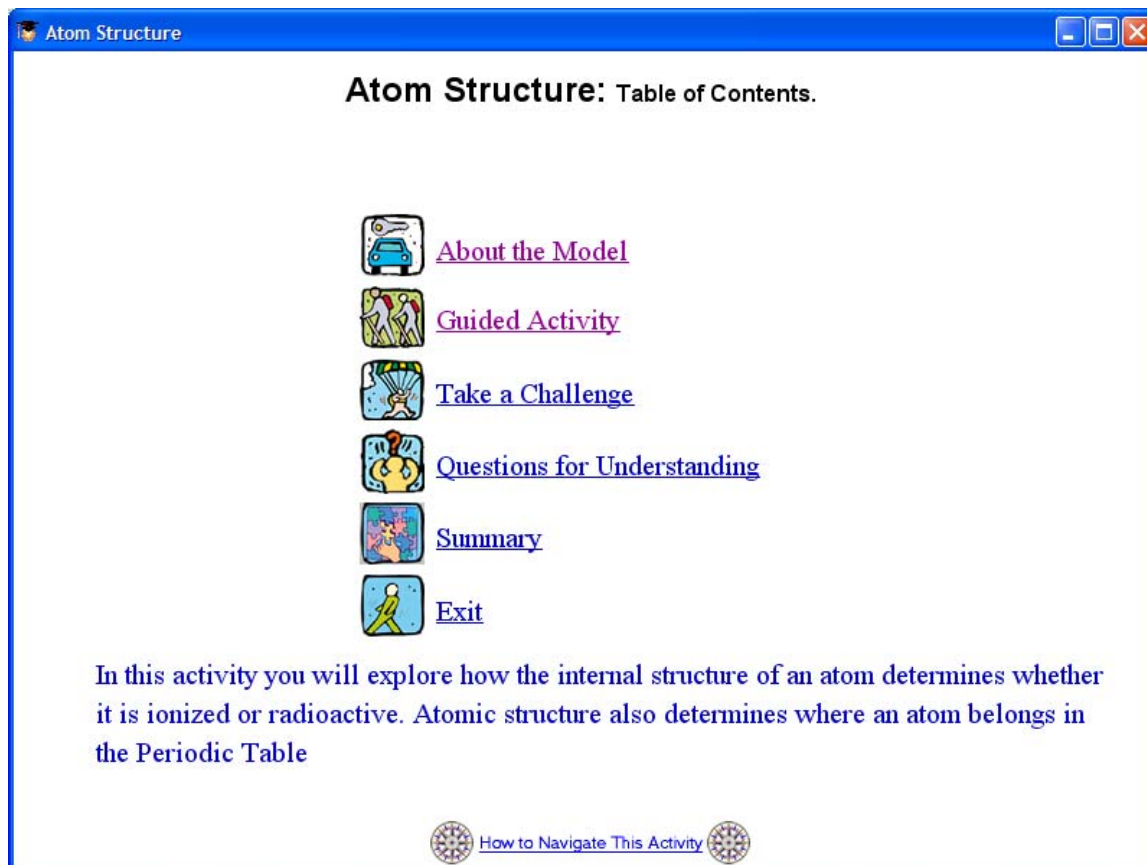
#### Alignment to National Math and Science Standards (NCTM or NSES)

Objective	Standards
<b>Students will understand how the ratio between neutrons and protons affects radioactivity.</b>	<ul style="list-style-type: none"><li>• Varies by state.</li></ul>
<b>Students will understand how the number of protons and electrons affects the charge of atom.</b>	<ul style="list-style-type: none"><li>• Varies by state.</li></ul>
<b>Students will understand that unstable atoms are likely to be reactive.</b>	<ul style="list-style-type: none"><li>• Varies by state.</li></ul>
<b>Students will be able to understand half lives.</b>	<ul style="list-style-type: none"><li>• Varies by state.</li></ul>

## 4.0 Activity Sections







### 4.1 Table of Contents

This activity has 5 sections.





The screenshot shows a window titled "Atom Structure" with a blue border. The main content area is white and contains the following text and icons:

**Atom Structure: Table of Contents.**

-  [About the Model](#)
-  [Guided Activity](#)
-  [Take a Challenge](#)
-  [Questions for Understanding](#)
-  [Summary](#)
-  [Exit](#)

In this activity you will explore how the internal structure of an atom determines whether it is ionized or radioactive. Atomic structure also determines where an atom belongs in the Periodic Table

 [How to Navigate This Activity](#) 

## 4.2 About the model

In this step students are reminded that atoms are made up of three different subatomic particles.:

**Atom Structure: About the model.**

Isotopes and Ions: Exploring the model.

Heat bath activated. T= 100

Add a proton (+1 charge)

Add a neutron (0 charge)

Add an electron (-1 charge)

Reset Atom to Hydrogen

p n e

isotope mass number

$^{14}_7\text{N}$

atomic number

Current Charge: +2

IONIZED

Atoms are the foundation of all matter. However, even atoms have an internal structure.

Atoms are made from 3 different subatomic particles: positive protons, neutral neutrons, and negative electrons. Protons and neutrons make up the nucleus of the atom, and the electrons surround the nucleus.

This next screen provides an overview of radioactivity:

**Atom Structure: About the model.**

**Isotopes and Ions: Exploring the model.**

Heat bath activated. T= 100

Add a proton (+1 charge)

Add a neutron (0 charge)

Add an electron (-1 charge)

Reset Atom to Hydrogen

p n e

isotope

mass number

$^{13}_7\text{N}$

atomic number

Current Charge: +2

IONIZED

**Radioactivity**

If the number of neutrons and protons are present in approximately equal amounts, the atom will be stable. If not, it will be radioactive and decay.

If the number of protons and electrons are not equal then there will be an imbalance of positive and negative charge, making the atom into an ion (a charged atom).

This activity allows you to experiment with different mixes of protons, neutrons, and electrons to make different kinds of atoms.

The third screen provides an overview of terms including:

- Atomic number
- The mass number
- Atomic weight

The screenshot shows a software window titled "Atom Structure" with a blue border. The title bar includes the text "Atom Structure" on the left and "...Node: about3" on the right, along with standard window control icons (minimize, maximize, close). The main content area has the title "Atom Structure: Exploring the model" centered at the top, with a yellow question mark icon to its right. Below the title, the text "Remember:" is followed by a bulleted list:

- The number of protons identifies the element.
- Atomic number = number of protons
- Mass number = number of protons + number of neutrons
- The atomic weight is almost, but not quite, equal to the mass number.

Below the list, the text reads: "Click the periodic table icon. A large periodic table will pop up. Click on the element "Mg" (Magnesium) to see it's atomic number. The atomic number is the number of protons that an element contains."

At the bottom of the window, there is a navigation bar with three icons: a blue curved arrow pointing left, a document icon, and a grey curved arrow pointing right. On the far right of this bar is a small icon of a periodic table.

It is worth noting that the students need to click on the periodic table in the lower left hand corner to continue. This table will provide information about each element. This information via the table is available during the rest of the exercise. Students should be encouraged to use this table when they need the information:

**Periodic Table**

H	IIA											III B	IV B	V B	VIB	VII B	VIII B	He																												
Li	Be											B	C	N	O	F	Ne																													
Na	Mg	IIIA	IVA	VA	VIA	VIIA	VIII	IB	IIB			Al	Si	P	S	Cl	Ar																													
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr																													
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe																													
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn																													
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub																																			
<table border="1"> <tr> <td>Ce</td><td>Pr</td><td>Nd</td><td>Pm</td><td>Sm</td><td>Eu</td><td>Gd</td><td>Tb</td><td>Dy</td><td>Ho</td><td>Er</td><td>Tm</td><td>Yb</td><td>Lu</td> </tr> <tr> <td>Th</td><td>Pa</td><td>U</td><td>Np</td><td>Pu</td><td>Am</td><td>Cm</td><td>Bk</td><td>Cf</td><td>Es</td><td>Fm</td><td>Md</td><td>No</td><td>Lr</td> </tr> </table>																			Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu																																	
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr																																	
Name		No.		Weight		Valence Shell																																								
Magnesium		12		24.305		[Ne]3s(2)																																								
Covalent R		Atomic R		Crystal		Electronegativity (Pauling)																																								
1.36		1.6		HCP		1.31																																								

Close

Click on MG and then Close the window

## 4.3 Guided activity

This section introduces the student to the model that allows the formation of different types of atoms by adding protons, neutrons and electrons:

**Atom Structure: Exploring the model**

Add a proton (+1 charge)  
Add a neutron (0 charge)  
Add an electron (-1 charge)  
Reset Atom to Hydrogen-1

p n e

isotope  
mass number  
1  
1  
H  
atomic number

Overall Atom Charge	Current Charge: 0
Atom Stability	

The model above shows a hydrogen atom. It has one proton, one electron and one neutron. The blue area represents the electron cloud. The green buttons allow you to add protons, neutrons and electrons to the atom. Adding these particles will create different types of atoms.

- Some atoms will have a charge and are called ions.
- Some atoms will be neutral and stable.
- Some atoms will be radioactive.

Click the next arrow to create atoms.

In the model students vary the number of each particle. It is worth noting that unstable atoms will break down if they are left too long. This simply resets the model back to hydrogen.

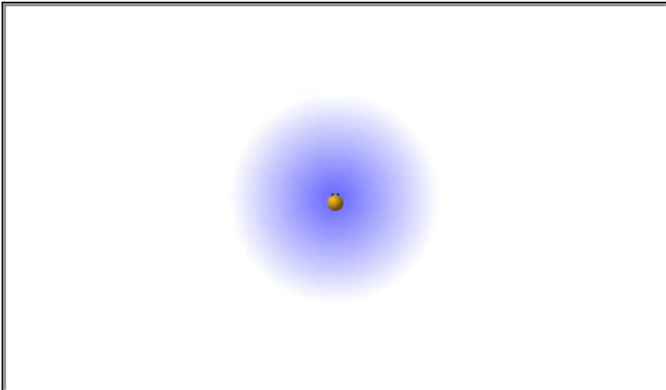


On the next page students are encouraged to play with the model. The subsequent page encourages more interaction by asking the students to look at the PNE table on the page. Please note that this table will change as the students add more particles:

Atom Structure
...Node: guide3

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✖

### Atom Structure: Exploring the model



Add a proton (+1 charge)

Add a neutron (0 charge)

Add an electron (-1 charge)

Reset Atom to Hydrogen-1


p	n	e
●	●	●

isotope
mass number
1
H
atomic number
1

Overall Atom Charge	Current Charge: 0
Atom Stability	

Using the controls above you can construct many different types of atoms. Some will have a charge (or be ionized) and some will be neutral. Some will be stable and some will be radioactive. Now, focus on the "p n e" table as you construct various atoms.

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↪



The next page asks students to use the model to uniquely identify the element. Please note that the atomic number uniquely identifies the element.  
 Atomic number = Number of protons  
 Mass number = Protons + Neutrons

**Atom Structure: Relating the isotope to the protons and neutrons.**

**Atom Structure: Relating the isotope to the protons and neutrons.**

Add a proton (+1 charge)    Add a neutron (0 charge)    Add an electron (-1 charge)    Reset Atom to Hydrogen-1

Overall Atom Charge	Current Charge: 0
Atom Stability	

Changing the protons and neutrons also makes changes in the isotope symbol listed to the right of the "p n e" table. Make adjustments to the number of protons and neutrons and notice how it changes the isotope.

**a. The symbol specifying the type of atom you created is related to which of the following?**  
 Atomic Number     Mass Number

**b. How are the atomic number and mass number related to the number of protons and/or neutrons?**

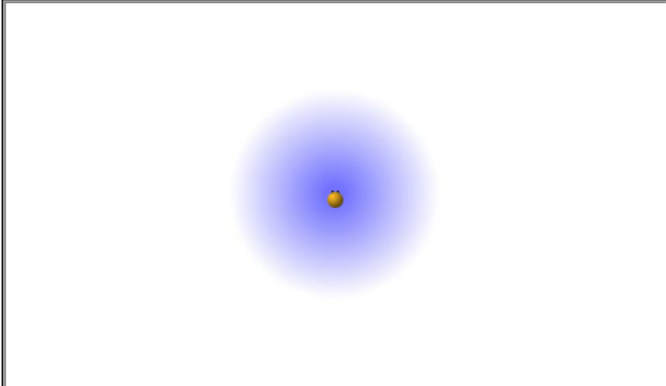
The next page asks students to observe that neutrons have no effect on the overall charge of the atom:

Then, once they have answered that question, the students must use the formula:

Protons – electrons = Charge. In this case,  $8 - 6 = 2$ .

Atom Structure ...Node: guide5

### Atom Structure: Determining the charge of an atom.



Buttons: Add a proton (+1 charge), Add a neutron (0 charge), Add an electron (-1 charge), Reset Atom to Hydrogen-1

Legend: p (red dot), n (grey dot), e (blue dot)

isotope:  ${}^1_1\text{H}$  (mass number 1, atomic number 1)

Overall Atom Charge	Current Charge: 0
Atom Stability	

Next to the "Overall Atom Charge" box is an indication of the current charge of the atom. If the atom has a charge, it is considered to be ionized. Experiment with adding positive protons, neutral neutrons and negative electrons to see how this affects the charge on an atom.

c. Which particle has no affect on the overall charge of the atom?

protons     neutrons     electrons

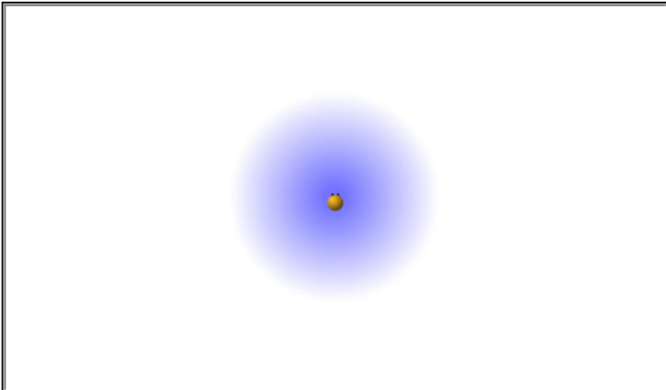
d. What would be the charge on an atom that has 8 protons and 6 electrons? Explain how you determined your answer.

Navigation icons: back, home, forward, periodic table

On the next page students choose the particle that does not impact radioactivity (the electron) and should be able to observe that atoms which have one proton for each neutron tend to be stable:

Atom Structure
...Node: guide6

Atom Structure: Creating radioactive and stable atoms.



p n e

● ● ●

isotope

mass number

1  
H  
1

atomic number

Add a proton (+1 charge)

Add a neutron (0 charge)

Add an electron (-1 charge)

Reset Atom to Hydrogen-1


Overall Atom Charge	Current Charge: 0
Atom Stability	

**If an atom is radioactive, that means its nucleus will be unstable. Experiment with adding protons, neutrons, and electrons to see how they affect the atom's radioactivity.**

**e. Which particle has no affect on the radioactivity of the atom?**

protons    
  neutrons    
  electrons

**f. What is the general rule for creating an atom with a stable nucleus (one that is NOT radioactive)?**

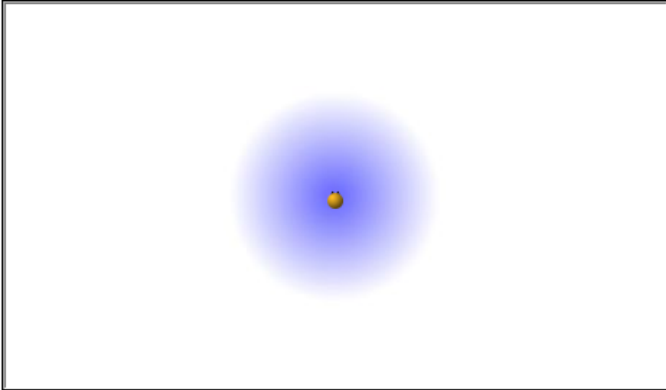


## 4.4 Take the challenge

In this first screen students are asked to ponder radioactivity. Radioactive atoms tend to break down because their nuclei do not have a correct number of neutrons (either too many or too few).

Atom Structure ...Node: challenge1

### Atom Structure: Creating a stable, neutral carbon atom.



Add a proton (+1 charge)    Add a neutron (0 charge)    Add an electron (-1 charge)    Reset Atom to Hydrogen-1

**p n e**  
● ● ●

**isotope**  
mass number  
 $^1_1\text{H}$   
atomic number

Overall Atom Charge	Current Charge: 0
Atom Stability	

Radioactive atoms all eventually "decay", which means they will shoot out pieces of their nuclei until they form a more stable nucleus.

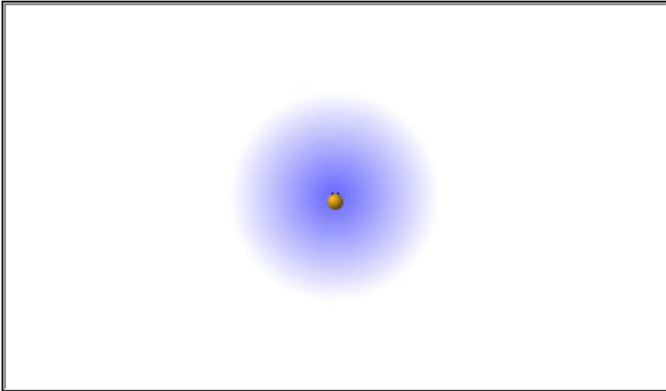
g. What makes an atom radioactive?

Navigation icons: back, help, forward, and a periodic table icon.

The next screen provides an overview of half-lives:

Atom Structure ...Node: challenge2

### Atom Structure: Creating a stable, neutral carbon atom.



Control panel:

- Add a proton (+1 charge)
- Add a neutron (0 charge)
- Add an electron (-1 charge)
- Reset Atom to Hydrogen-1

Legend: p n e

isotope

mass number

atomic number

Overall Atom Charge	Current Charge: 0
Atom Stability	

- The time it takes for an atom to break down is called a half life.
- During each half life, 1/2 of a group of atoms breaks down into a different element or isotope.
- This breakdown occurs in all radioactive elements.
- Some radioactive elements will last a billionth of a second and others will last a billion years.

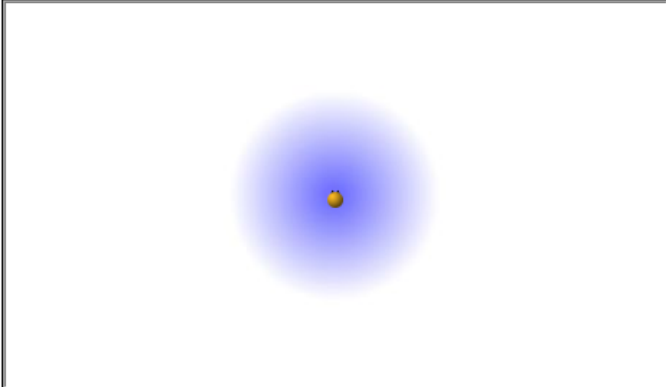
Navigation icons: back, help, forward

The next screen asks students to draw some conclusions about radioactive elements. When an atom breaks down it forms a new element and gives off energy. Students should see that energy is released when the atoms break down. The change into a new element is less visible, but nevertheless should be able to be surmised by the students.

Atom Structure
...Node: challenge3

⏪
⏩
✖

### Atom Structure: Creating a stable, neutral carbon atom.



Add a proton (+1 charge)

Add a neutron (0 charge)

Add an electron (-1 charge)

Reset Atom to Hydrogen-1

p	n	e	isotope
●	●	●	mass number
			${}^1_1\text{H}$
			atomic number

Overall Atom Charge	Current Charge: 0
Atom Stability	

**h. What do you think happens to the atoms that are radioactive?**

they get bigger  
 they change into other elements  
 they give off energy  
 b & c

**i. Explain your reasoning:**

⏪
📄
⏩
🏠

The next screen will ask students to make a stable carbon atom. It must be done in 10 seconds or the atom will break down. Students may need to refer to the periodic table in the lower left hand corner to look up the atomic number of carbon. It is important that particles are added evenly; otherwise the atom will break down.

**Atom Structure: Creating a stable, neutral carbon atom.**

Buttons: Add a proton (+1 charge), Add a neutron (0 charge), Add an electron (-1 charge), Reset Atom to Hydrogen-1

Overall Atom Charge	Current Charge: 0
Atom Stability	

isotope:  ${}^1_1\text{H}$  (mass number 1, atomic number 1)

For the purpose of this challenge, all the radioactive atoms you create will decay in 10 seconds. Your challenge is to create a stable (non-radioactive) carbon atom with no overall charge.

Students will then be asked to make an Oxygen ion with a -2 charge. This will mean that the atom will need 8 protons, 8 neutrons and 10 electrons. The extra electrons will generate the minus 2 charge on the atom, making it an ion. When the atom is complete, students should choose the "check atom" button.



## 4.5 Questions for understanding

This section asks the students a series of questions.

Question j: The nucleus is made up of protons and neutrons.

Question K: Assuming a 1:1 ratio of protons to neutrons, an atom with 8 protons would need 8 neutrons to be non-radioactive.

Question m: using the formula protons- electrons, this would give us a charge of -1.

**Atom Structure: Questions for Understanding**

**j. Which two subatomic particles are used to make the nucleus of an atom?**

xxxx

**k. If you had an atom with 8 protons, how many neutrons would you need to make the element radioactive:**

8

**l. Explain your answer:**

xxxxx

**m. What is the charge of an atom that has 6 protons, 6 neutrons and 7 electrons?**

12

-1

0

1

**n. Explain your answer:**

xxxxx

Navigation icons: back, forward, and a document icon. A 'Hint' button is also present.

## 4.6 Summary

This section shows the answers to all the questions. There is an icon on the lower left that will print each student's answers.

## 5.0 Student Reports

Your students' work with the Orbital activity is logged and viewable on the MAC Project Web Portal at <http://mac.concord.org>. For each student, you can view a report containing questions and answers.

The next activity in the Chemica sequence is "Electric Fields and Orbitals."