Electric Fields and Orbitals

Teacher's Guide

1.0 Summary

Electric Fields and Orbitals is the fourth activity to be done after the pre-test. This activity should take approximately 20 minutes.

2.0 Learning Goals

Driving Question: How do electrical fields interact in an atom ?

This activity provides an overview of the electrical relationships that occur within an atom. Students will be able to manipulate point charges, widespread charges and another hydrogen atom and observe their effects on a central hydrogen atom. This model will enable students to observe how the electric fields change in response to each other. It will also enable the students to observe the overlap that takes place when two electron clouds are close together. This overlap forms the basis of the chemical bond which holds atoms together when the form molecules.

Learning Goals

- Students will review that electrons are negatively charged.
- Students will understand that like electric fields repel each other.
- Students will understand that unlike electric fields attract each other.
- Students will understand that electron orbitals can interact to form covalent chemical bonds.
- Students will understand that covalent bonds are the result of electron sharing or overlapping.

Additional Teacher Background

Molecules are formed when atoms share electrons. This sharing occurs when the electron orbitals overlap and are mutually attracted to more than one nucleus. The stable molecule formed by these bonds will usually have less energy than the original two atoms.

The distance between the two atoms is controlled both by the repulsive force of the two nuclei and by the attractive force of the electron clouds (orbitals). Atoms will arrange themselves in a way that minimizes the energy between them.

Because the orbitals are fluid, they will readjust themselves in order to minimize their repulsion to other negatively charged objects and maximize their attraction to positively charged objects.

3.0 Standards Alignment

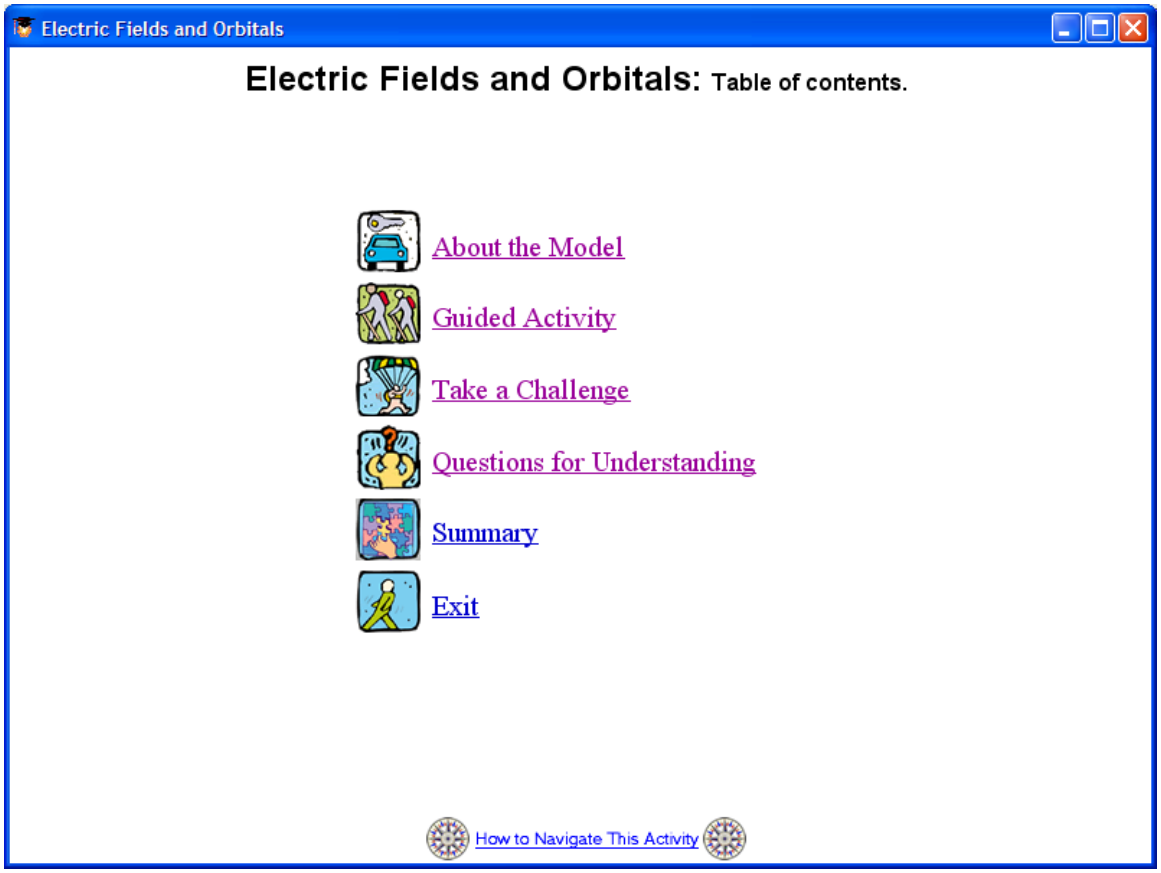
Alignment to National Math and Science Standards (NCTM or NSES)

Objective	Standards
Students will understand that electric fields interact with each other thus: opposites attract and like charges repel.	• Varies by state.
Students will understand that orbitals overlap to form covalent bonds.	• Varies by state.
Students will understand that electric orbitals are not always symmetrically arranged around the nucleus.	• Varies by state.
Students will understand that electrons hold nuclei together by forming covalent bonds.	• Varies by state.

4.0 Activity Sections

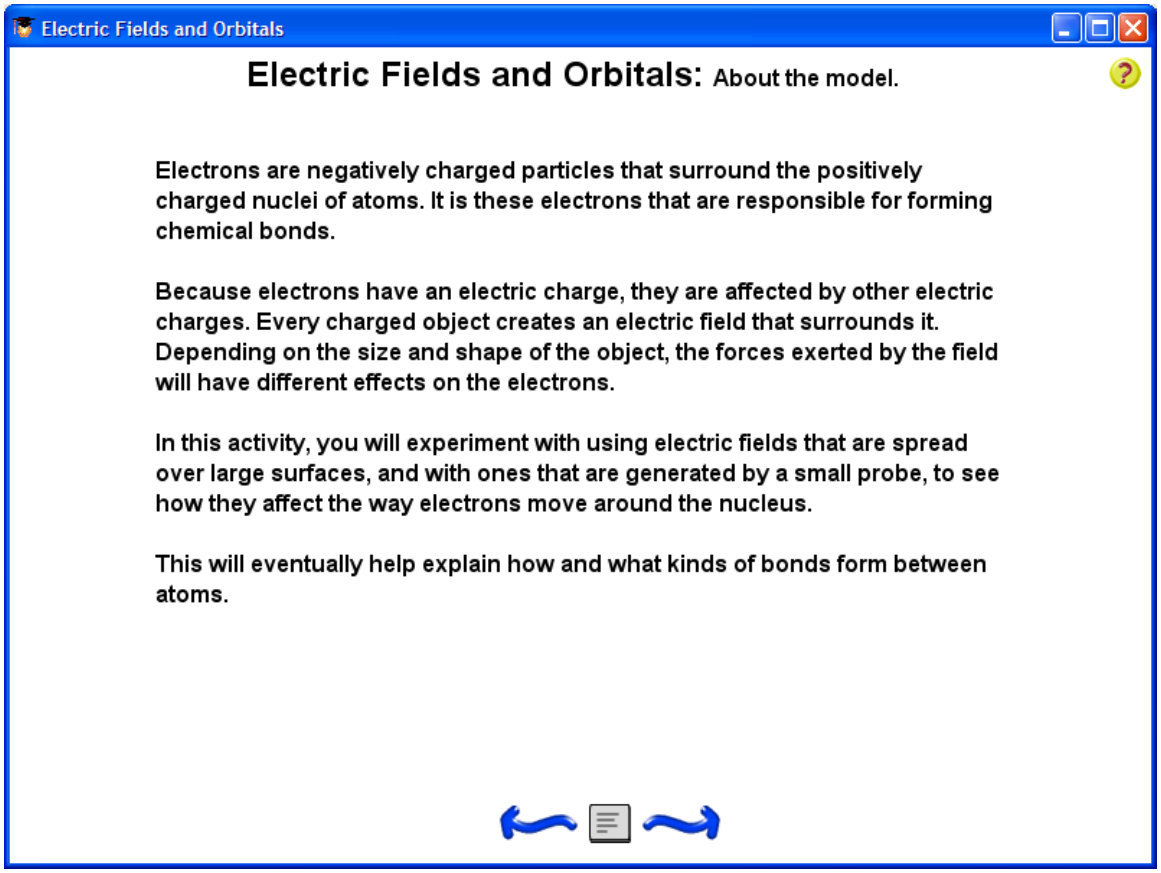
4.1 Table of Contents

The *Electric Fields and Orbitals* activity has 5 sections.



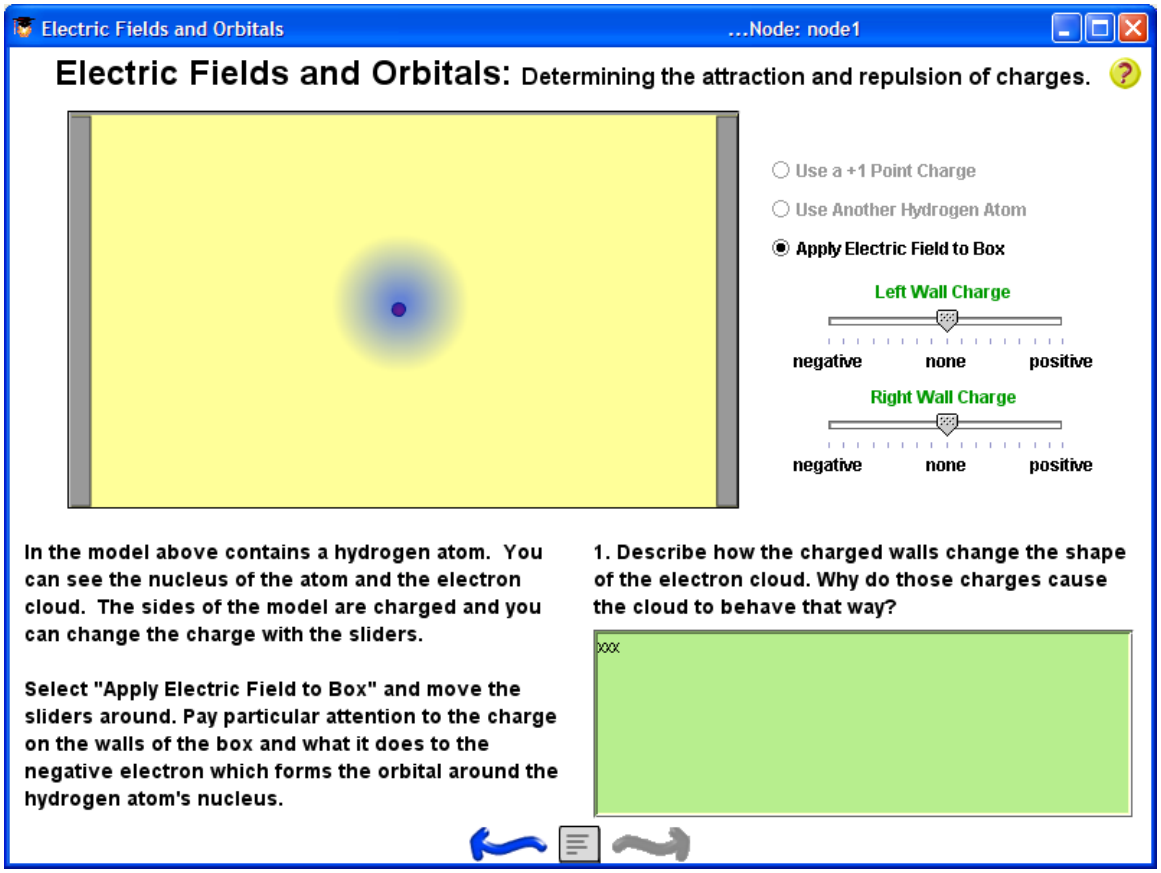
4.2 About the Model

In this step students are reminded that electrons are negatively charged particles and that these charges will move around when subjected to other charges. It also provides a brief overview of the model.

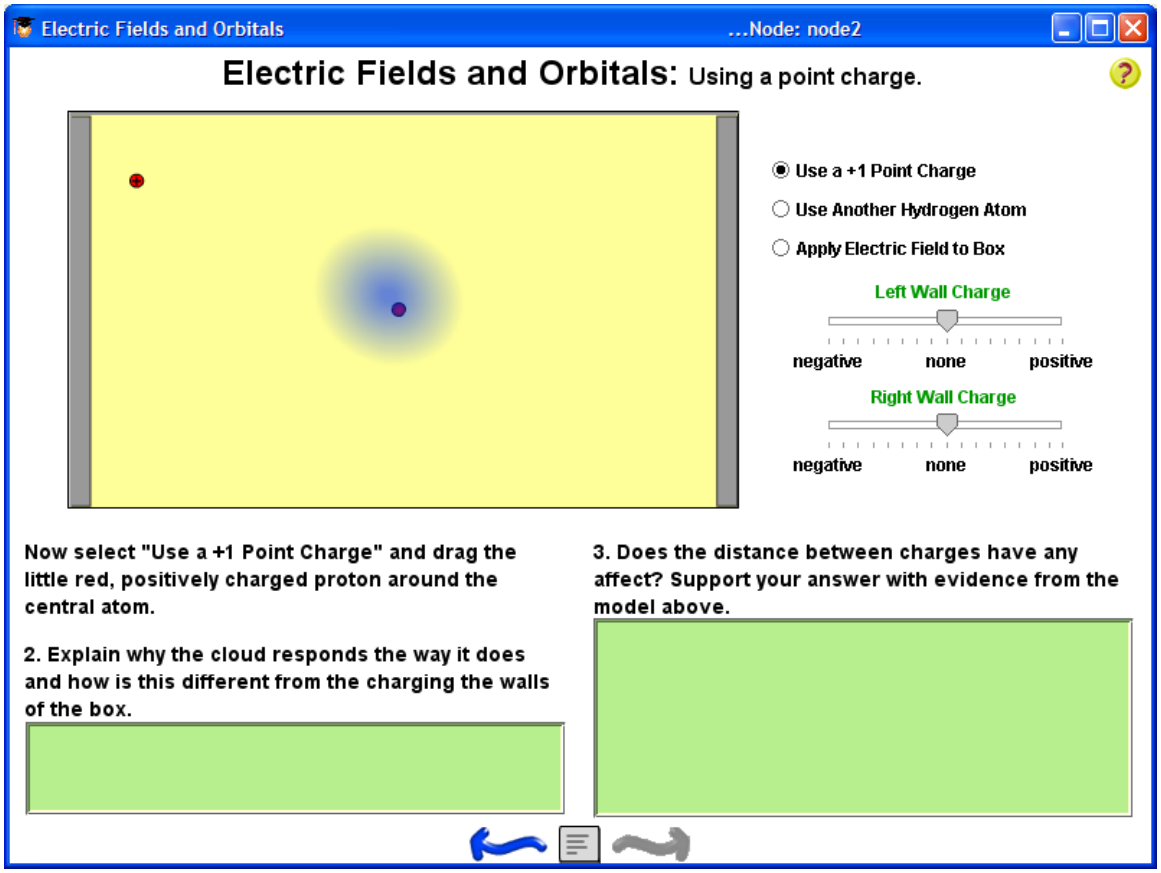

Electric Fields and Orbitals
Electric Fields and Orbitals: About the model.
Electrons are negatively charged particles that surround the positively charged nuclei of atoms. It is these electrons that are responsible for forming chemical bonds.
Because electrons have an electric charge, they are affected by other electric charges. Every charged object creates an electric field that surrounds it. Depending on the size and shape of the object, the forces exerted by the field will have different effects on the electrons.
In this activity, you will experiment with using electric fields that are spread over large surfaces, and with ones that are generated by a small probe, to see how they affect the way electrons move around the nucleus.
This will eventually help explain how and what kinds of bonds form between atoms.

4.3 Guided activity

This section introduces the student to the model, which allows the manipulation of three different electric fields. On this page students are asked to experiment with the “Apply electric field to box” button. This allows students to change the polarity and the charge intensity of the vertical walls of the box. It is worth noting how the blue orbital changes its shape as the fields are altered. The blue orbital field is negatively charged and will move towards positive charges and away from negative charges.

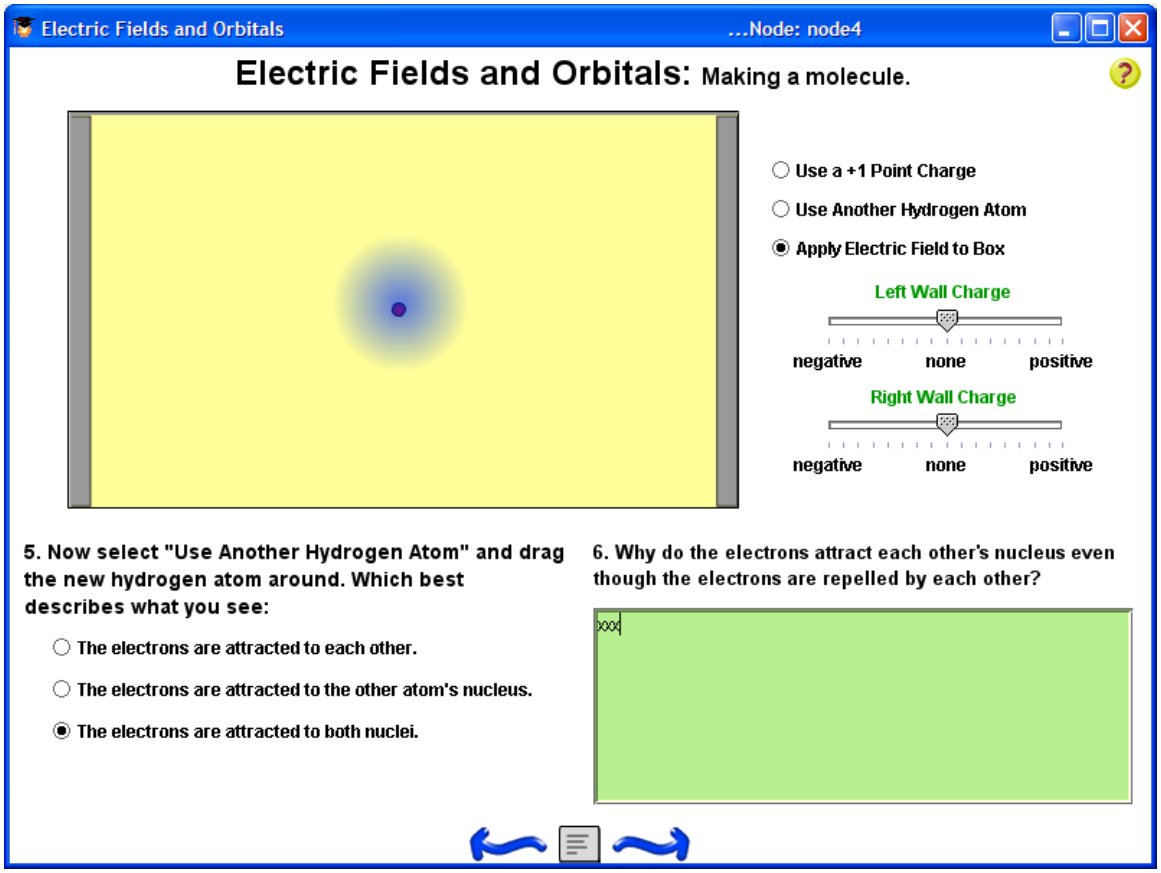


On the next screen, students experiment with a “point charge.” This is essentially a proton, which has a positive charge. The model permits the charge to be dragged around the central hydrogen atom. It is worth noting that the blue orbital will move towards the proton because of the proton’s positive charge. The field strength is also dependent upon distance, so the distortion of the blue orbital will be greatest when it is close. This point charge is more concentrated and more mobile than the wall charges on the previous screen. Therefore it will produce different patterns in the orbital:

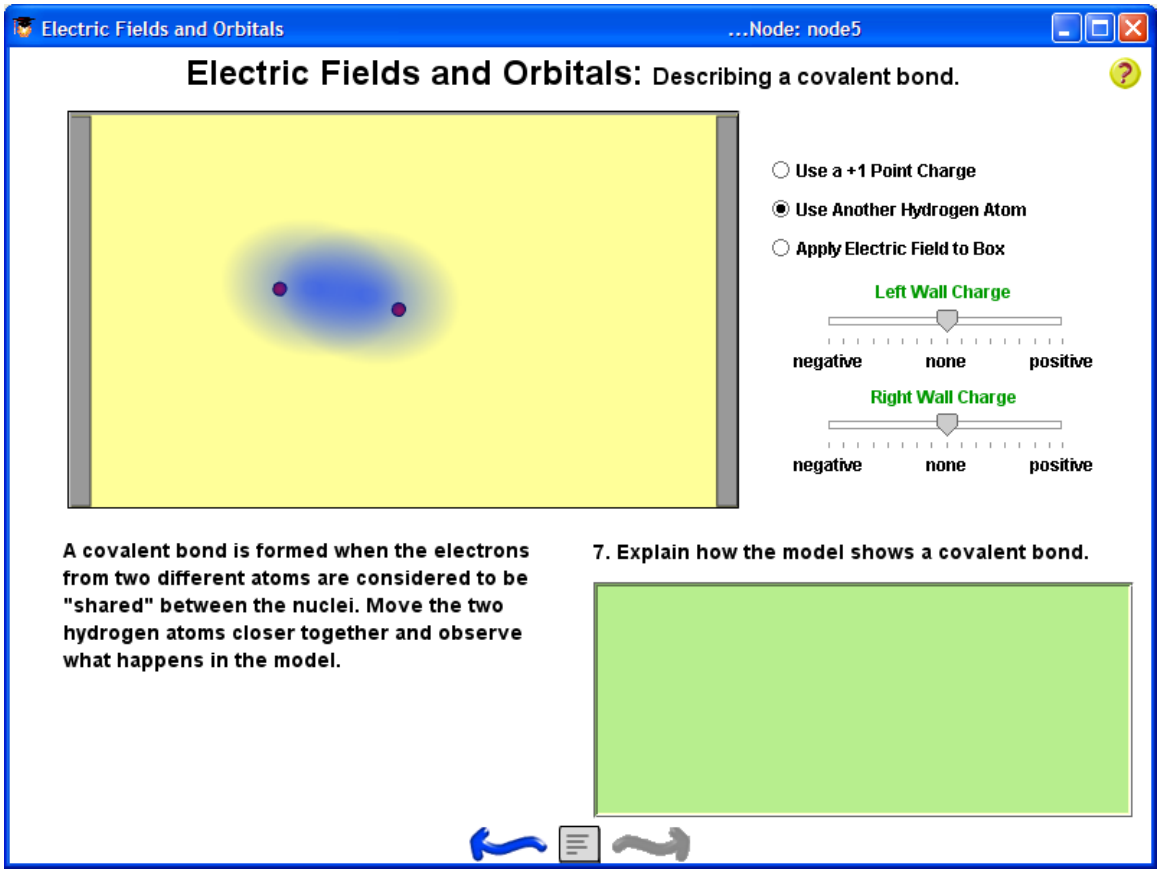


The next screen asks: “Why can the point charge not overlap with the nucleus of the hydrogen atom?” It is worth noting that each of these objects has a positive charge; therefore, they will repel each other.

On the next screen, students experiment with another hydrogen atom. Unlike the last screen, the proton is now surrounded with an electron in the form of an orbital. This orbital, like the other, carries a negative electric charge. These orbitals will be attracted to the positive nuclei of both atoms when they are moved close together; otherwise, they will only be attracted to the nucleus of their own atom. “The electrons are attracted to both nuclei” is the best answer on this screen. Electrons, which make up the blue orbitals, will move towards any positively charged object and away from any negatively charged object. Other orbitals carry a negative charge.

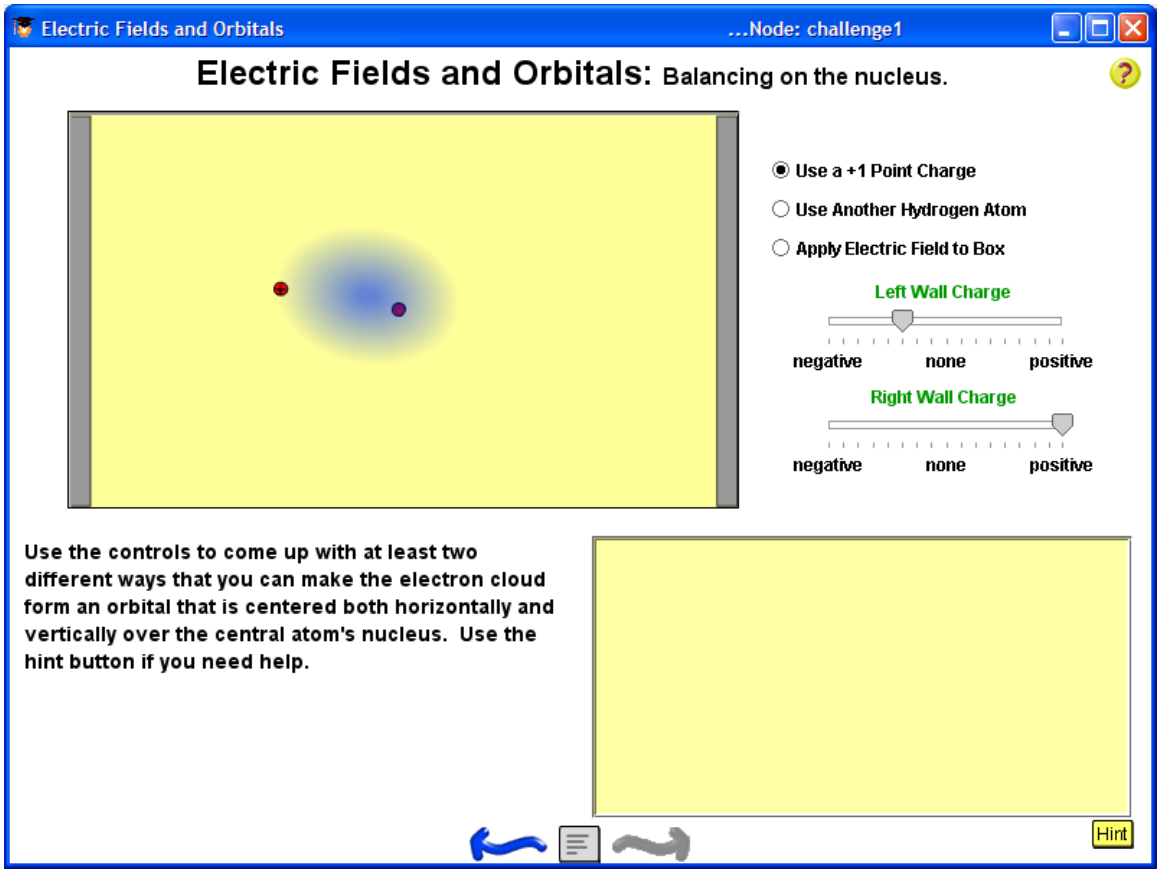


When two hydrogen atoms are moved close together, the orbitals overlap. This is similar to the “sharing of electrons” which is often used to describe covalent bonds. This overlap is the result of the orbitals being attracted to both nuclei. The dark blue region indicates a strong electron density between the two nuclei. This implies that the electrons are being shared by both nuclei. This represents a covalent bond:

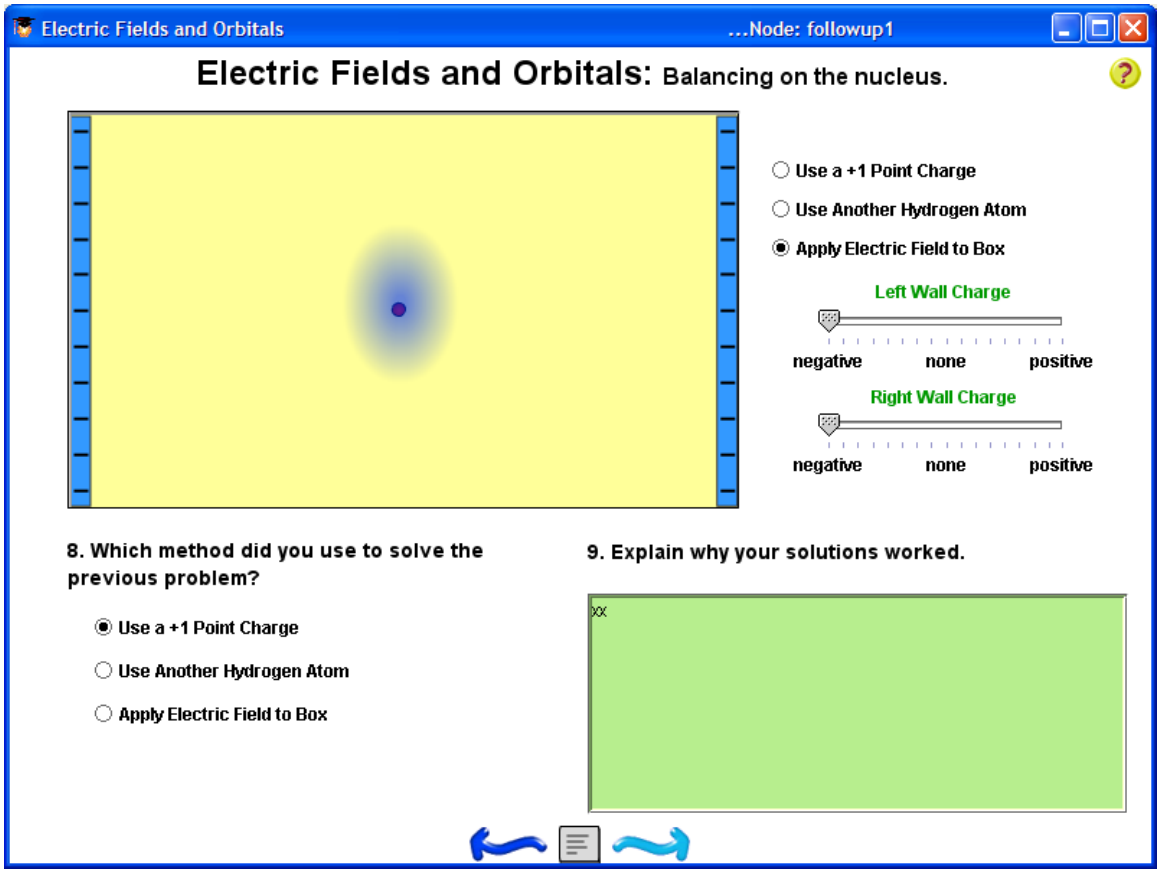


4.4 Take a challenge

In this first screen students are asked to generate a symmetrical blue orbital using two different settings. This can be accomplished by using the “Apply Electric Field to Box” button. Then, as long as the sliders are set to the same value, the orbital will be symmetrical on both the vertical and horizontal plane:



The next screen asks which solution worked and why. The electric fields allowed the production of a symmetrical orbital because the opposing wall could balance the electric field. All other solutions provide no way to offset the charge of either the proton or hydrogen atom. The small area of these other two charges would also make it more difficult to cancel out and generate a symmetrical orbital:



4.5 Questions for understanding

This section asks the students a series of questions.

Question 10: What is the charge of an electron?
The electron has a negative charge.

Question 11: The charge of an atom's nucleus is:
The nucleus is made up of protons and neutrons. Neutrons are neutral and protons carry a positive charge. Therefore, the nucleus is positive.

Question 12: Compare how an electron cloud (orbital) responds to a positive charge and how an electron cloud responds to a negative charge.
The electron cloud is made up of negatively charged electrons. This cloud will move away from other negatively charged objects and toward positively charged objects.

Question 13: What is a covalent bond?
A covalent bond is the overlap that occurs between two orbitals in two atoms. The mutual attraction of the orbital for the two positively charged nuclei causes these electrons to form a region of high density between the two nuclei. This attraction holds the two nuclei together and forms a covalent bond.

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. After a student clicks the icon, s/he will be asked to type in her/his name. This is only for the printout; the names are not saved in our database. Then, a web page is generated with the answers. This process may take a few moments. The standard print dialog box will open and the student can select the appropriate printer.

5.0 Student Reports

Your students' work with the Electric Fields and Orbitals 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 *Types of Bonds*.