PhET Tips for Teachers   **Build an Atom**

Tips for controls:
- You must drop protons and neutrons near the center "X" in the model, and drop electrons near the orbits. In interviews, students did not need to be told to drag in the particles.
- The four boxes on the right: **Element, Symbol, Mass Number, Net Charge** are displays, you cannot interact with them. All but the Element box are closed on startup to reduce the initial complexity.
- We included options to hide the readouts in the play area (e.g., **Show Element Name**) so teachers can ask prediction questions during class discussion.

Important modeling notes / simplifications:
- The sim is called "Build an Atom" but students can build neutral atoms *and* ions.
- The nucleus is magnified to allow for interaction – you may want to address this in a class discussion or have a question in your lesson. The radii of the orbits in the Bohr model are also not in the correct ratio.
- We define a "**Stable**" isotope as one whose half-life is too long to be measured; see also http://www.webelements.com/isotopes.html. The nucleus of an "**Unstable**" isotope vibrates, but we do not allow it to fly apart.
- Although some ions are unlikely to occur in nature like H^{-9}, since there is no clear agreement as with isotopes, we decided to let students explore any number of electrons. We use the notation -3 instead of 3- to indicate ions.
- We include the **Cloud Model** along with the Bohr Model to reinforce that both are only *models* of the atom; this meets science standards about the nature of scientific models. In the Cloud Model, the shape of the cloud is not that of the actual orbital, and the size of the cloud is not meant to denote true atomic or ionic radius; the cloud simply gets larger and darker as you increase the number of electrons.
- We do not allow excited states; thus, if a student removes an electron from an inner shell, an outer shell electron falls into the hole; in reality, it would also emit a photon.

Information regarding the game tab:
- The game is provided to help students build skills, some students toggle back to the first tab to test their ideas and this seems helpful.
- The levels are designed to help students scaffold through all the learning goals, but do not need to be done in sequence.

Insights into student use / thinking:
- In interviews with students in grades 4-8, and in middle school classrooms, we found that students did not understand the word "**Unstable**" until we made the nucleus vibrate. In the same interviews, we found that students in early grades (4-6) could not fully interpret the "**Symbol**", but older students (7-8) figured it out on their own. The sim helps students learn the structure of an atom, but students tend not to notice "**Neutral Atom**" vs. "**Ion**" until the first level in the game.

Suggestions for sim use:
- For tips on using PhET sims with your students see: **Guidelines for Inquiry Contributions** and **Using PhET Sims**
- The simulations have been used successfully with homework, lectures, in-class activities, or lab activities. Use them for introduction to concepts, learning new concepts, reinforcement of concepts, as visual aids for interactive demonstrations, or with in-class clicker questions. To read more, see **Teaching Physics using PhET Simulations**
- For activities and lesson plans written by the PhET team and other teachers, see: **Teacher Ideas & Activities**

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