



## Science Objectives

- Students will determine that the number of protons in the nucleus defines the identity of the element.
- Students will determine that the number of neutrons in the nucleus determines its stability, but does not change the identity of the element.
- Students will determine that the nucleus of light elements is stable when the ratio of protons to neutrons is about 1:1.
- Students will determine that the number of electrons in the atom influences the size of the atom.
- Students will determine that electrons can only be located at discrete distances from the nucleus, called electron shells.
- Students will define the atomic number and the mass number.
- Students will correctly use the atomic symbol,  ${}^Z_A X^C$ , where X is the element symbol, Z is the mass number, A is the atomic number, and C is the net charge of the atom.

## Vocabulary

- |              |                     |
|--------------|---------------------|
| • proton     | • atomic symbol     |
| • neutron    | • atomic number     |
| • nucleus    | • mass number       |
| • electron   | • isotope           |
| • net charge | • electron shell    |
| • ion        | • valence electrons |
| • element    |                     |

## About the Lesson

- This lesson involves students manipulating an atom's composition and observing the change in atom identity, stability, overall charge, size, and atomic symbol.

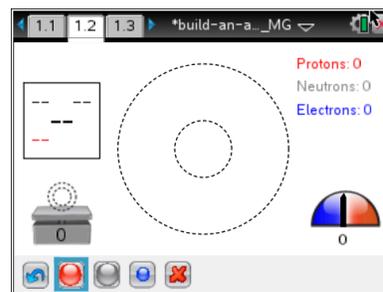


### TI-Nspire™ Navigator™

- Send and collect files.
- Monitor student progress using Class Capture.
- Use Quick Poll to assess students' understanding.
- Use Live Presenter for students to share their work and present results of explorations.
- Use Slide Show to give students feedback on assessment.

## Activity Materials

- Compatible TI Technologies:  TI-Nspire™ CX Handhelds,  TI-Nspire™ Apps for iPad®,  TI-Nspire™ Software
- Periodic Table of Elements (optional)



## Tech Tips:

- This activity includes screen captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at <http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials>

## Lesson Files:

### Student Activity

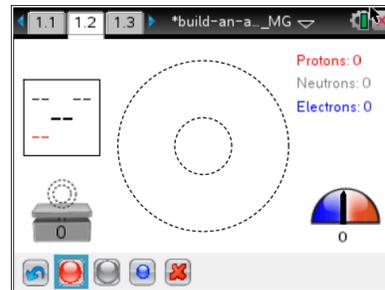
- Build\_an\_Atom\_Student.doc
- Build\_an\_Atom\_Student.pdf
- build-an-atom\_HS.tns



### Discussion Points and Possible Answers

#### Move to page 1.2.

In this activity students will add protons, neutrons and electrons to build an atom and observe the relationship between the number of particles and the properties of the atom. Select  to add a proton. Select  to add a neutron. Select  to add an electron. To remove the particle, select the proton, neutron, or electron and then use  to remove.



#### Part 1: Identity of the Element

1. In this simulation the mass number, the net charge, and the atomic symbol automatically update. The simulation will also show the properties of the atom you constructed: whether it is an ion or neutral atom, and when the atom is unstable. Students record observations for each combination in a table.



**Tech Tip:** To remove particles, use the grab tool  to first select the particle and then select  to remove the particle.

Q1. What happens when you change the number of protons keeping the numbers of other particles the same?

**Answer:** The number of protons determines the identity of the element. Also, the atomic number, the mass number, and the net charge change.

Q2. What happens when you change the number of neutrons keeping the numbers of other particles the same?

**Answer:** The number of neutrons does not change the identity of the element. Also, the atomic number and the net charge do not change, but the mass number changes.

Q3. What happens when you change the number of electrons keeping the numbers of other particles the same?

**Answer:** The number of electrons does not change the identity of the element. The atomic number and the mass number also do not change. However, the net charge changes.



#### TI-Nspire Navigator Opportunities

Allow students to volunteer to be the Live Presenter and demonstrate the effect of changing the number of a particular particle on properties of the atom. Use Quick Poll to check for understanding during the course of the activity. The question 4 could be used as a Quick Poll.



Q4. Based on your observations, answer the following questions about atomic symbol:

a. What is atomic number?

**Answer:** The number of protons.

b. What is mass number?

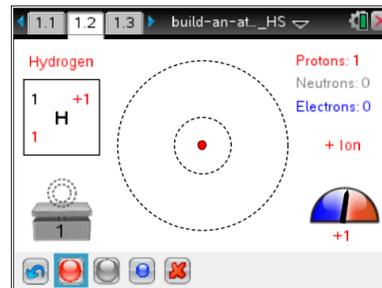
**Answer:** The number of protons and neutrons together.

c. What is the net charge?

**Answer:** The difference in the number of protons and electrons.

### Part 2: Nucleus Stability

2. Students will now explore the relationship between the protons and neutrons for the nucleus to be stable. Students should reset  the simulation, start with one proton and add neutrons, and then record all stable combinations (isotopes) in the table below. They should continue the simulation until they use all available protons. The first two rows of the table are completed for students as an example.

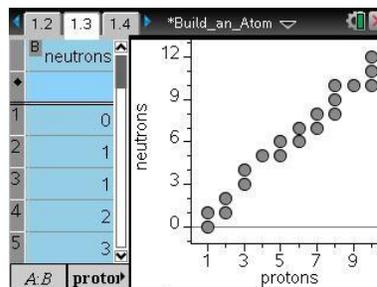
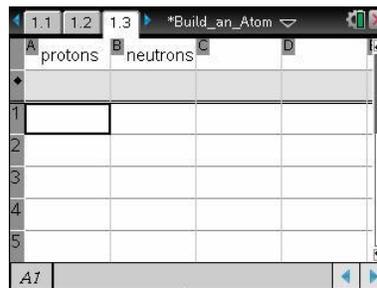


Element	Number of Protons	Number of Neutrons	Element	Number of Protons	Number of Neutrons
H	1	0	C	6	7
H	1	1	N	7	7
He	2	1	N	7	8
He	2	2	O	8	8
Li	3	3	O	8	9
Li	3	4	O	8	10
Be	4	5	F	9	10
B	5	5	Ne	10	10
B	5	6	Ne	10	11
C	6	6	Ne	10	12



Move to page 1.3.

- The page displays a *Lists & Spreadsheet* application. Column A is labeled **protons** and column B is labeled **neutrons**. Students should enter collected data in corresponding columns.
- Students should follow the steps below to create a scatter plot using their handheld.
  - Select both lists, place the cursor in a cell in the **protons** column, and continue to press  $\blacktriangle$  until the entire list is highlighted.
  - Press and hold  $\text{⇧}$ , and press  $\blacktriangleright$  to highlight both lists
  - Release  $\text{⇧}$ .
  - Press **Menu > Data > Quick Graph**.
  - A scatter plot will be created with the list to the left as the independent variable list.
- Students can use **Doc > Page Layout > Custom Split** and then  $\blacktriangleleft$  and  $\blacktriangleright$  to adjust the scatter plot window.



**Tech Tip:** To create a scatter plot, select  **> Data > Quick Graph**. Students can then add variables to the desired axes. Note that in some cases, a student may need to back-out to the main Tools Menu  to see the desired menu option.

- Q5. What is the average ratio between the number of protons and number of neutrons that provides for a stable isotope?

**Sample Answer:** The ratio is about 1:1. In order to justify that students can find the best fit line, the slope of the line will represent the average ratio of neutrons to protons.

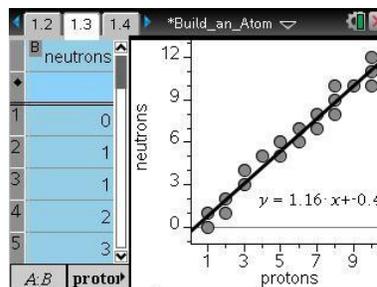


**Tech Tip:** To switch between windows of a split screen, students will need to press  $\text{ctrl}$   $\text{tab}$ .

6. In order to add the best fit line, students should select **Menu > Analyze > Regression > Show Linear**. The regression line and equation will appear on the scatter plot.

- Q6. What is the meaning of the slope of the best fit line?

**Answer:** The slope represents the average ratio of neutrons to protons in a stable isotope. It is 1.16 based on regression line.



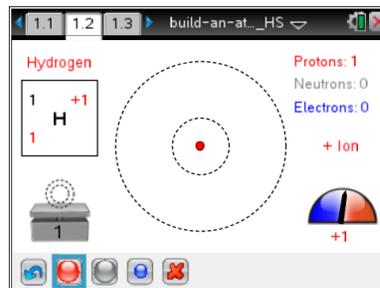


**Tech Tip:** Be sure to have the graph screen active. To create a best fit line, select > Analyze > Regression > Show Linear. You may need to back-out to the main Tools Menu to see the desired menu option.

**Part 3: The Size of an Atom**

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7. Students will explore how placement of electrons affects the size of an atom. They will also determine that the electrons can only be placed on electron shells that are located at discrete distances from the nucleus. Remind students that shells are numbered starting from innermost shell. In the simulation only two shells are shown,  $n = 1$  and  $n = 2$ .



8. Students should start with Hydrogen isotope with 1 proton only. They will add one electron at a time and record their observations in the table below. When describing the size, students should state whether size increased, decreased, or did not change. Students will use these observations to answer questions.

Total Number of Electrons	Net charge	Number of Electrons in Shell $n = 1$	Number of Electrons in Shell $n = 2$	Size
1	0	1	0	Increased
2	1	2	0	Did not change
3	2	2	1	Increased
4	3	2	2	Did not change
5	4	2	3	Did not change

Q7. What did you notice about how the electrons were placed as you added them to the Hydrogen atom?

**Answer:** Electrons could be placed only on the shells at fixed distances from the nucleus. Only two electrons could be placed on the shell  $n = 1$ , all other electrons went to the larger shell  $n = 2$ .



Q8. What happens to the size of the atom as you add electrons? Do you see a pattern?

**Answer:** The atom got bigger when you added the 1<sup>st</sup> electron, it did not change when you added 2<sup>nd</sup> electron, since it was placed on the same shell as the first one and then it got even bigger when you added the 3<sup>rd</sup> electron.

9. Students will now explore the position of chemical elements in the Periodic Table and placement of electrons in a neutral atom. For each chemical element, students should record the shell where the last electron is placed to build a neutral atom. The electrons on the outermost shell are called **valence** electrons.

H   $n = 1$  , He   $n = 1$  , Li   $n = 2$  , Be   $n = 2$  , B   $n = 2$  ,  
C   $n = 2$  , N   $n = 2$  , O   $n = 2$  , F   $n = 2$  , Ne   $n = 2$

Q9. Which elements have valence electrons only on the shell  $n = 1$  when atom is neutral? Where are these elements located in the periodic table?

**Answer:** The elements are H and He. They are in the 1<sup>st</sup> row of the Periodic Table, Period 1.

Q10. Which elements have valence electrons in the shell  $n = 2$  when atom is neutral? Where are these elements located in the periodic table?

**Answer:** The elements are Li, Be, B, C, N, O, F, and Ne. They are in the 2<sup>nd</sup> row of the Periodic Table, Period 2.



### TI-Nspire Navigator Opportunities

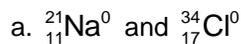
Use Quick Poll to check for understanding during the course of the activity. Questions 10 and 11 could be used for Quick Poll. After collecting the answer, make sure to ask students to explain their reasoning.

Q11. Where would you expect the valence electrons to be placed for sodium and iron?

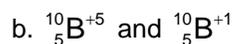
**Answer:** the valence electrons for sodium are in the shell  $n = 3$ , since Na is in the 3<sup>rd</sup> row of the Periodic Table, the valence electrons for iron are in the shell  $n = 4$ , since Fe is in the 4<sup>th</sup> row of the Periodic Table.



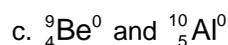
Q12. Compare the sizes of the following atoms. Explain your reasoning for each case:



**Answer:** The size of  ${}_{11}^{21}\text{Na}^0$  is about the same as  ${}_{17}^{34}\text{Cl}^0$ , since both are in the same row of the Periodic table and thus they have valence electrons in the same shell.



**Answer:** The size of  ${}_{5}^{10}\text{B}^{+5}$  is smaller than  ${}_{5}^{10}\text{B}^{+1}$ , since  ${}_{5}^{10}\text{B}^{+5}$  does not have any electrons and thus has a size of nucleus.  ${}_{5}^{10}\text{B}^{+1}$  has 4 electrons, so the size is determined by the size of electron shell  $n = 2$ .

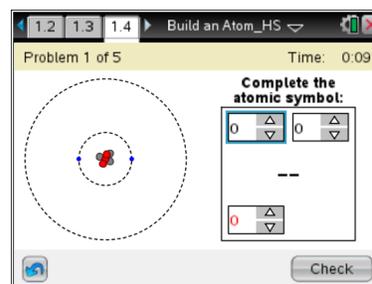


**Answer:** The size of  ${}_{4}^9\text{Be}^0$  is smaller than the size of  ${}_{5}^{10}\text{Al}^0$ , since  ${}_{4}^9\text{Be}^0$  is in row 2 and  ${}_{5}^{10}\text{Al}^0$  is in row 3, and  $n = 2$  shell is closer to the nucleus than  $n = 3$  shell.

### Part 4: Build an Atom Game

#### Move to page 1.4.

As students complete the activity, they can move to the last page to play a game that assesses their understanding of atomic symbol. The game has 4 levels. Students can select the level in the lower left corner.



Each game has 5 questions. For each question there are two tries. On the second try, students press “Show Answer” to see the correct answer.

There are two types of questions. One where you are given the atomic symbol and the other where you are given the number of protons, etc. Students can score up to 10 points on each game.



#### TI-Nspire Navigator Opportunities

Use Class Capture to monitor the game. Use Quick Poll to collect student scores.

### Wrap Up

When students are finished with the activity, collect students' worksheets.

### Assessment

- Formative assessment will consist of questions embedded in the student worksheet. Analyze questions in the student worksheet with the students. Teacher can also collect scores that students earned in the game.
- Summative assessment will consist of questions/problems on the chapter test.