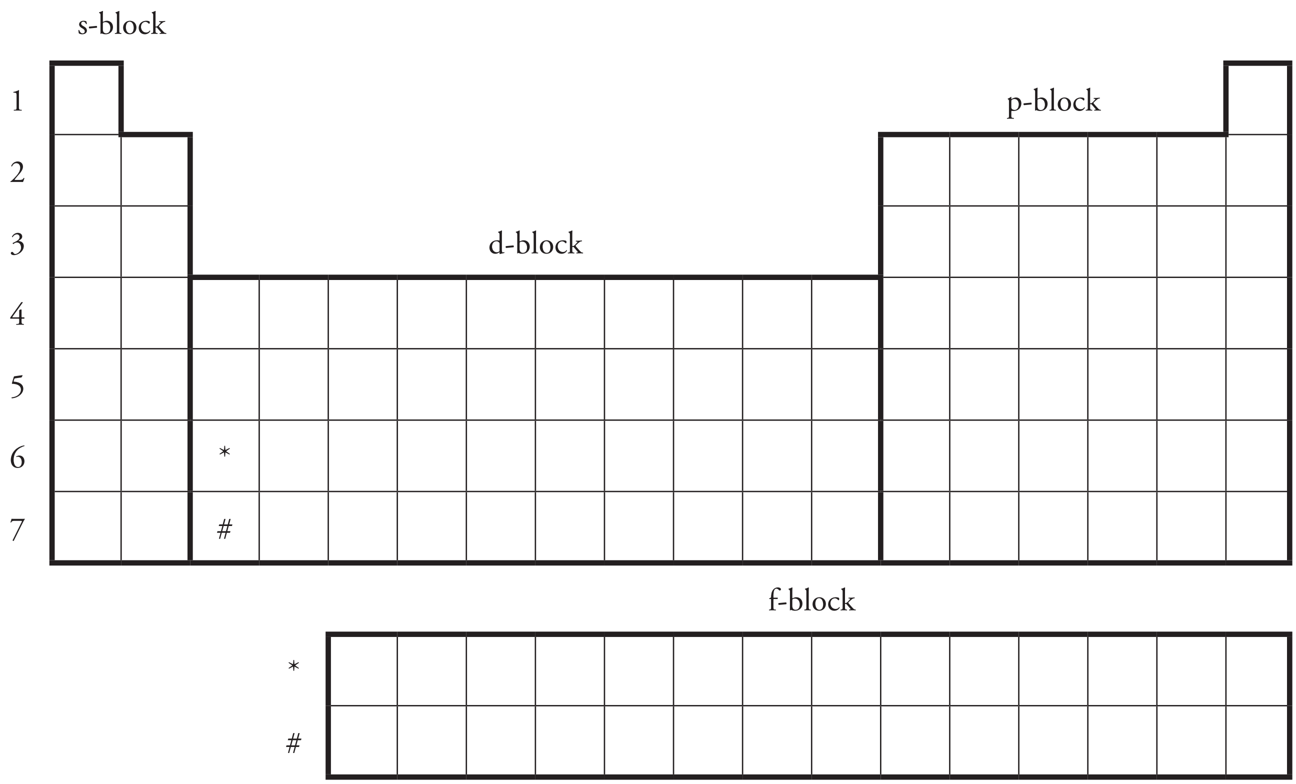
Cracking the Periodic Table Code

Why aren't the elements listed in alphabetical order?

Why?

As charts go, the periodic table is a bit odd. It's not square. Large portions of the table appear to be missing at the top. It's not organized alphabetically so elements can be found easily. But to a chemist, the periodic table is a very powerful tool. The periodic table is organized by properties, both chemical and physical. Those properties relate to the electronic structure of the atoms of each element. In today's activity, you are going to study how the ground state electron configurations and structure of atoms are related to the shape and organization of the periodic table.

Model 1 – Blank Periodic Table



1. Obtain a card with electron configurations for your group as assigned by your teacher.
   a. Record your team number______ and team name ___________________________________.
   b. For each element on your card, write the last orbital notation appearing at the end of the configuration (the underlined portion).

2. What is similar about the last orbital notation appearing at the end of the configuration for each element in your set?

3. Locate where your set of elements should be in Model 1.

   a. Write the last orbital notation in the electron configuration for each element in your set in its respective box.

   b. What is the relationship between your answer in Question 2 and the "block" of the table where your set of elements is located?

4. What is the relationship between the last orbital notation in your set of ground state electron configurations and the row numbers on the left-hand side of the periodic table in Model 1?

Read This!

Go on a search—send a representative of your group to other tables to find out what they have discovered in Questions 1–4. Add the last orbital notation for their groups of elements to Model 1. Talk to at least one team from each of the "blocks" (*i.e.,* you want to look at a set of elements in the s-block, d-block, p-block, and f-block). It is NOT the goal of this activity to fill in the entire periodic table. You just need a few data points in each section to answer the questions that follow.

5. Count the number of columns in each of the four "blocks" of the table in Model 1. What is the relationship between the "block" size and the number of electrons that will fit in the corresponding atomic sublevel?

6. What is the relationship between where an element is located within a "block" of the table in Model 1 and the superscripted (raised, like an exponent) value appearing at the end of the electron configuration for that element?

7. Obtain the Electron Energy Levels handout from your teacher. Put the Electron Energy Levels handout next to Model 1. Start at the bottom of the Electron Energy Levels handout with the 1s energy sublevel and locate the section of the periodic table corresponding to that sublevel. Why are there only two elements in the first row of the periodic table?

8. Work your way up the Electron Energy Levels diagram, locating as many sublevel sections as you can on Model 1.

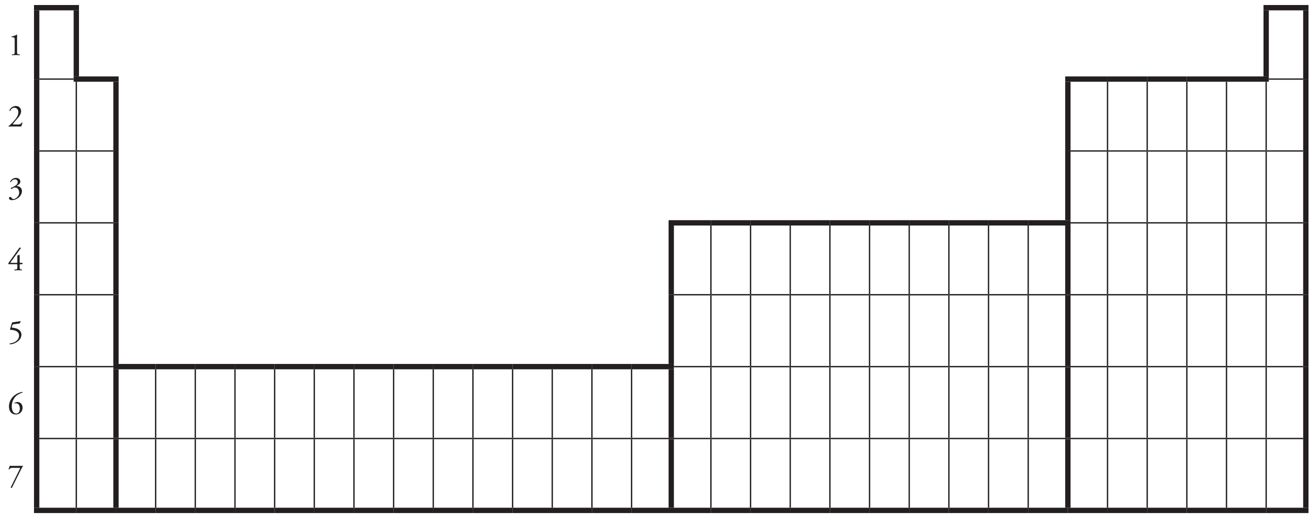
   a. Why does the second row of the periodic table not have a "d-block" section?

   b. The third energy level in an atom contains a d sublevel. Why then does the "d-block" start in the fourth row of the periodic table?

9. For the elements of the "d-block" how is the row number related to the principal energy level for the last orbital notation of their electron configurations?

10. Obtain from your teacher the Periodic Table handout and a pair of scissors. Cut out the sections as instructed and reassemble the periodic table sequentially by atomic number.

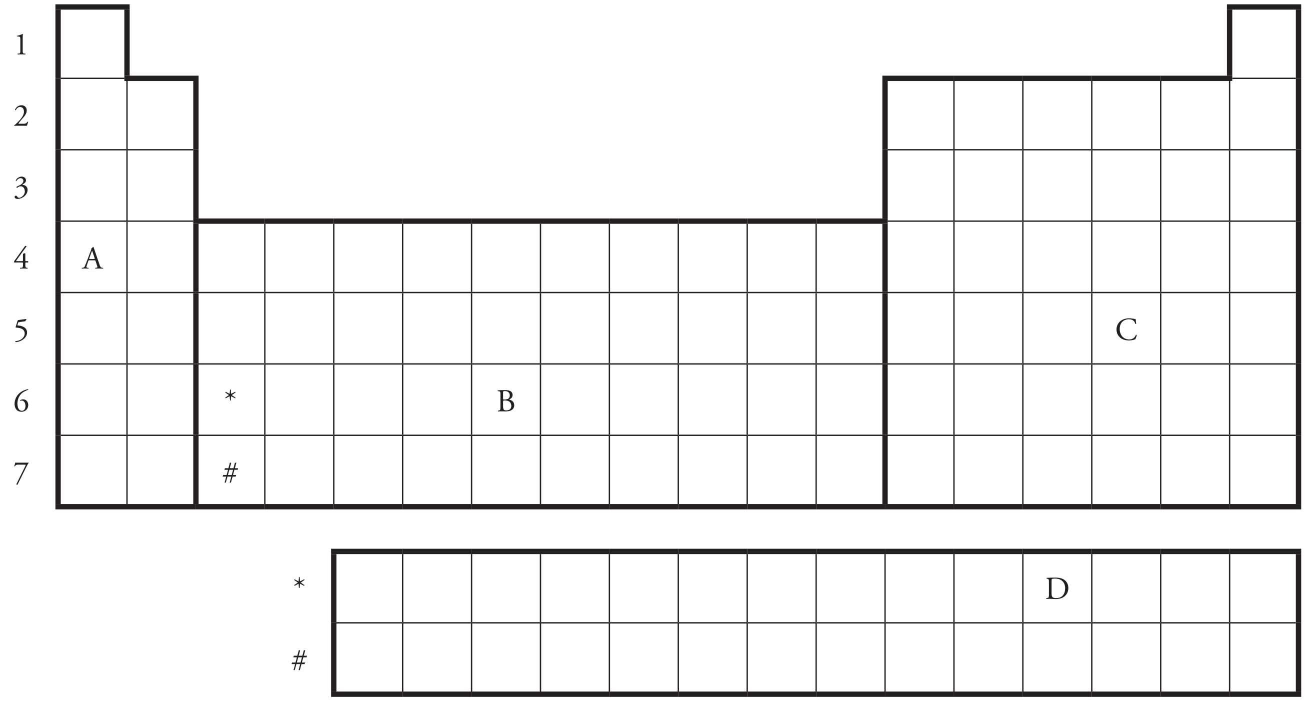
Model 2 – Periodic Table (Long Form)



11. Use your group's reconstructed periodic table to label the sections of Model 2.
12. Compare the periodic table of Model 1 with the periodic table of Model 2. What section of the table was moved?
13. What do the * and # symbols in Model 1 indicate?
14. The form of the periodic table seen in Model 2 is called the "long form" of the table. You do not often see this form in books or posters. What are the disadvantages of this form?
15. Explain why the "f-block" does not appear until the 6th row, and why it fits in-between the "s" and "d" blocks. (*Hint:* Refer to the Electron Energy Levels handout.)
16. For the elements in the "f-block," how is the row number related to the principal energy level for the last orbital notation of their electron configurations?"

STOP

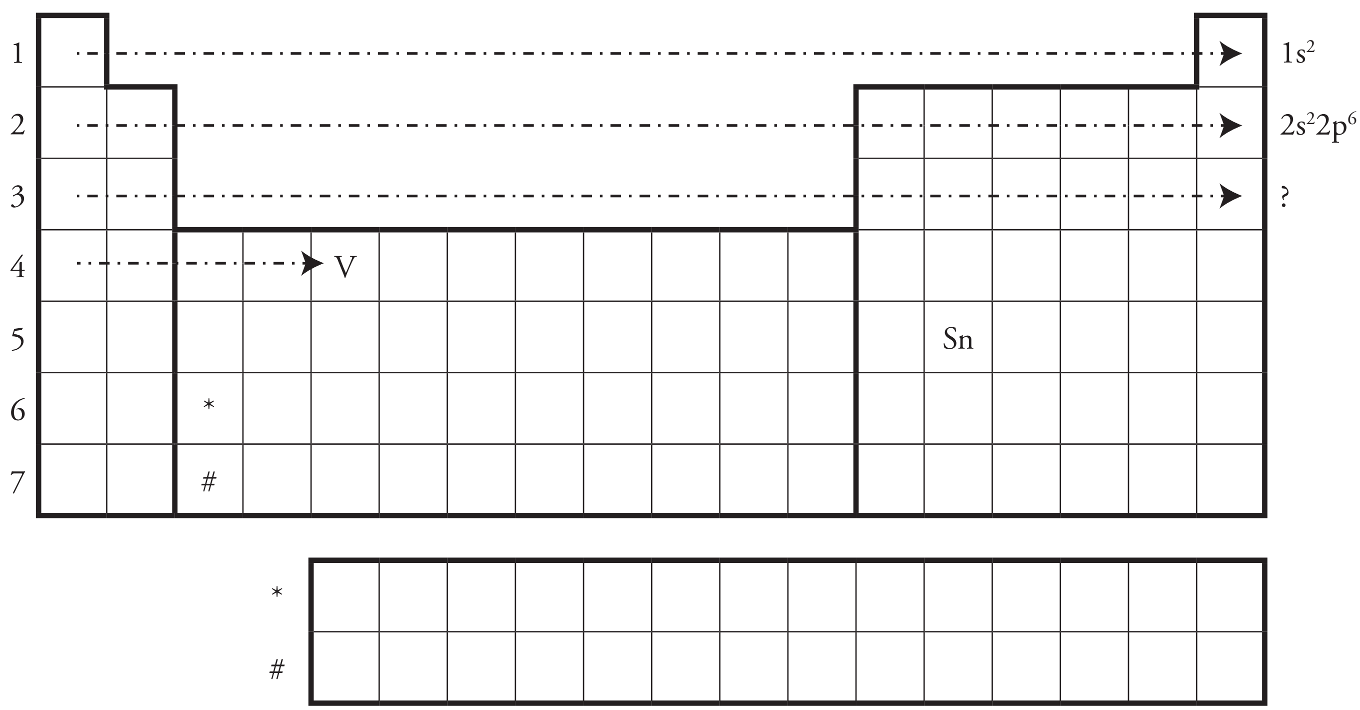
17. Write the last orbital notation in the electron configurations for the elements located at A, B, C, and D in the table below. You should not have to "count" electrons to do this if you understand the structure of the periodic table.



A ____________________ B ____________________

C ____________________ D ____________________

Model 3 – Use of the Periodic Table for Electron Energy Levels



18. Now that you understand how the structure of the periodic table relates to electron sublevels, you can use it as a "cheat sheet" for the order of filling of electrons in the sublevels of the atom. The following steps will help you write the ground state electron configuration for vanadium, V.

    a. Use your finger to trace a line across the top row of the periodic table in Model 3. Explain why the two boxes in that row represent $1s^2$.

    b. Trace a line across row two of the periodic table. Explain why this row represents $2s^2 2p^6$.

    c. Trace a line across row three of the periodic table. Record the sublevels and number of electrons that will be filled by the time you reach the end of this line.

    d. Trace a line across row four ending at vanadium, V, and record the sublevels and number of electrons that are filled to reach that point.

    e. Combine the steps above to write the full ground state electron configuration for vanadium (V).

19. Using only a periodic table, write the full ground state electron configuration for an atom of tin (Sn).

20. The electron configuration for an unknown element is:

    $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^6 7s^2 5f^{14} 6d^4$

    a. Identify the element and write its symbol in its proper location of Model 3.

    b. Describe two different methods that could be used to identify this element.

Extension Questions

Model 4 – Predicted versus True Configuration

	Predicted Configuration	**True Configuration** (Supported by scientific evidence)
Cr	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$
Cu	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^9$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$
Ce	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^2$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^1 5d^1$

21. For each of the elements in Model 4, circle the portion of the true electron configuration that differs from the predicted configuration.

22. Construct a possible explanation for why the true configurations would be a lower potential energy state for the elements in Model 4. *Hint:* What types of atomic interactions cause a lower potential energy or higher potential energy? How far apart in energy are electrons in the higher energy levels?