Inferring the Characteristics of an Element
(Student textbook pages 188-9)

11. Write complete and condensed electron configurations for yttrium, Y.

What Is Required?
You need to determine the electron configuration for the given element and then write it in complete and in condensed form.

What Is Given?
You are given the element yttrium, Y.

Plan Your Strategy	Act on Your Strategy
Determine the atomic number of yttrium which will give you the number of electrons in the neutral atom.	The atomic number of yttrium is 39. Therefore, the neutral atom has 39 electrons.
Follow the guidelines for filling orbitals that are given on page 184 of the student textbook.	Use the order of orbitals shown on page 182 to determine the order of filling energy levels $1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p < \ldots$.
For each occupied orbital, write the electron configuration in the form $n(\text{symbol for } l)^{\text{number of electrons in orbital}}$. The complete electron configuration includes symbols for all occupied orbitals. Write the symbols, keeping track of the number of electrons. Stop at 39.	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^1$
The condensed electron configuration includes the symbol for the nearest, smaller noble gas in square brackets and then the symbols for occupied orbitals that contain valence electrons. The first eight orbital notations are identical to the noble gas, krypton, Kr.	$[Kr]5s^2 4d^1$.

Check Your Solution
If you add the values in the exponents of the complete electron configuration you get 39, which is correct for yttrium. The first eight symbols all have filled orbitals, which is consistent with noble gases.

12. Write complete and condensed electron configurations for lead, Pb.

What Is Required?
You need to determine the electron configuration for the given element and then write it in complete and condensed forms.

What Is Given?
You are given the element lead, Pb.

Plan Your Strategy	Act on Your Strategy
Determine the atomic number of lead which will give you the number of electrons in the neutral atom.	The atomic number of lead is 82 therefore the neutral atom has 82 electrons.
Follow the guidelines for filling orbitals which are given on page 184 of the student textbook.	($1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p < ...$)
For each occupied orbital, write the electron configuration in the form $n(\text{symbol for } l)^{\text{number of electrons in orbital}}$ The complete electron configuration includes symbols for all occupied orbitals. Write the symbols, keeping track of the number of electrons. Stop at 82.	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^2$
The condensed electron configuration includes the symbol for the nearest, smaller noble gas in square brackets and then the symbols for occupied orbitals that contain valence electrons. The first eleven orbital notations are identical to the noble gas, xenon, Xe.	[Xe] $6s^2 4f^{14} 5d^{10} 6p^2$

Check Your Solution
If you add the values in the exponents of the complete electron configuration you get 82, which is correct for lead. The first eleven symbols all have filled orbitals, which is consistent with noble gases.

13. What elements have the valence electron configuration that is given by ns^2?

What Is Required?
Determine which elements have a given electron configuration.

What Is Given?
You are given the electron configuration ns^2.

Plan Your Strategy	Act on Your Strategy
Analyze the electron configuration to determine which features are similar and which can vary.	The principle quantum number *n* can be any value. The highest orbital within an energy level is the *s* orbital. Therefore, the elements must be in the s block of the periodic table. The *s* orbital has 2 electrons, which fills the orbital. The elements must be in the second column of the *s* block elements.
Use this information to narrow the range of eligible elements.	All of the elements in Group 2 of the periodic table

Check Your Solution
All elements in Group 2 have two valence electrons. Therefore, they all include s^2 in their electron configuration.

14. What elements have the valence electron configuration that is given by $ns^2(n - 1)d^3$?

What Is Required?
Determine which elements have a given electron configuration.

What Is Given?
You are given the electron configuration $ns^2(n - 1)d^3$.

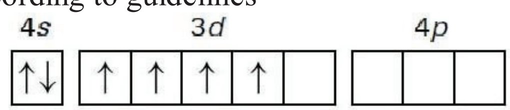
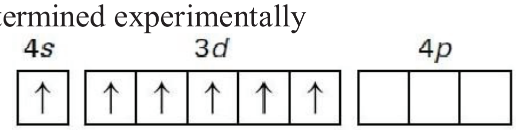
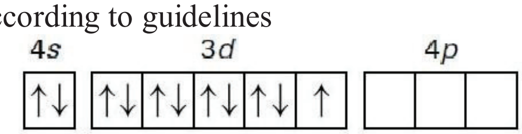
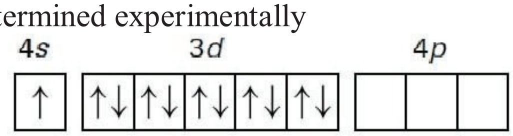
Plan Your Strategy	Act on Your Strategy
Analyze the electron configuration to determine which features are similar and which can vary.	The principle quantum number *n* can have any value. The elements must have valence electrons with a filled *s* orbital. There must be three electrons is the *d* orbital that has a principle quantum number that is one less than the principle quantum number of the valence electrons in the *s* orbital.
Use this information to narrow the range of eligible elements.	The elements will be in the *d* block. Elements in only Period 4 and greater have electrons in *d* orbitals. Therefore, *n* must have a value of 4 or higher. In Periods 4 and above, the *d* orbitals, with a principle quantum number that is one less than that of the *s* orbital, begin to fill after the *s* orbital is filled. Therefore, the elements must have 5 electrons (2 in the *s* orbital and 3 in the *d* orbital). Elements in Group 5 have five valence electrons. Therefore, the elements that fit the electron configuration, $ns^2(n - 1)d^3$, are in Group 5 of Periods 4 and above. These elements are vanadium, V; niobium, Nb; tantalum, Ta; and dubnium, Db.

Check Your Solution
All elements in the *d* block of Group 5 have five valence electrons. Therefore, they all include d^3 in their electron configuration.

15. What are the two exceptions to the guidelines for filling orbitals in Period 4? Draw the partial orbital diagrams you would expect for them, based on the aufbau principle. Then draw partial orbital diagrams that represent their actual electron configurations. Finally, explain why the discrepancy arises.

What Is Required?
You need to find elements which are exceptions to the guidelines for filling orbitals and explain why they do not fill orbitals according to the guidelines. Draw orbital diagrams of the theoretical configurations and the correct configurations.

What Is Given?
You are given Period 4 and told that there are two exceptions to the guidelines.

Plan Your Strategy	Act on Your Strategy
These data are experimental so you must find a source of electron configurations and determine those that have unfilled orbitals that theoretically are at lower energy levels than others that have begun to fill.	Find a periodic table that contains electron configurations or inspect Table 3.5 on page 186 of the student text to find the exceptions to the guidelines. You will find that the elements chromium, Cr, and Cu, copper, have 4*s* orbitals with only one electron even though there are electrons in the 3*d* orbitals that should be at a higher energy.
To draw orbital diagrams, draw boxes for 4*s*, 3*d*, and 4*p* orbitals and add the correct number of electrons, first according to the guidelines and then the correct diagrams.	Cr according to guidelines  Cr determined experimentally  Cu according to guidelines  Cu determined experimentally 

Plan Your Strategy	Act on Your Strategy
To explain why these configurations exist, you must determine a reason why these exceptions might have overall lower total stability than those for which the orbitals fill according to the general sequence for energy of orbitals.	Comparison of the theoretical and experimental orbital diagrams for chromium shows that the 3*d* orbitals are exactly half filled, whereas in the theoretical diagram, there is no such pattern. Therefore, when all of the 3*d* orbitals are half filled, the configuration is more stable than the theoretical configuration. Comparison of the theoretical and experimental orbital diagrams for copper shows that the 3*d* orbitals in the experimental diagram are completely filled, whereas, in the theoretical diagram they are not. Therefore, completely filling the 3*d* orbitals must confer stability on the electron configuration more than does filling the *s* orbital. In summary, when the 3*d* orbitals are either all half-filled or all completely filled, the configuration becomes stable, even if the *s* orbital is not filled.

Check Your Solution

Cr and Cu are the only elements in Period 4 of the *d* block elements that have one electron in the *s* orbital and at least one or more electrons in the *d* orbital of the valence electrons.

16. The condensed electron configuration for strontium is [Kr]5s^2. Without using a periodic table, identify the group number to which strontium belongs. Show your reasoning.

What Is Required?
You must determine the group number of an element from its electron configuration without consulting a periodic table.

What Is Given?
You are given the electron configuration for strontium, [Kr]5s^2.

Plan Your Strategy	Act on Your Strategy
For all *s*, *p*, and *d* block elements, the number of valence electrons corresponds to the group number. The exponents in the orbital symbols show the number of electrons that occupy the orbital.	Since there are two valence electrons in strontium, it must be in Group 2.

Check Your Solution
A periodic table confirms that strontium is in Group 2.

17. Identify the following elements and write condensed electron configurations for atoms of each element.
a. The *d*-block element in Period 4 with 10 valence electrons.
b. The element in Period 6 with 3 valence electrons.

What Is Required?
You must identify elements given information about the period and the number of valence electrons. Once the elements are identified, you must write the condensed electron configuration.

What Is Given?
You are given the data:
a. The *d*-block element in Period 4 with 10 valence electrons.
b. The element in Period 6 with 3 valence electrons.

a. The *d*-block element in Period 4 with 10 valence electrons.

Plan Your Strategy	Act on Your Strategy
For all elements other than *f*-block elements, the number of valence electrons corresponds to the group number. The principle quantum number of the *s* orbital corresponds to the period number.	Since there are no *f*-block elements below Period 6, you can use the number of valence electrons to determine the group number.
Determine the block and period numbers and, using a periodic table, find the element.	The element is in Group 10. When you look for the element in Group 10 of Period 4, you will find that it is nickel.
When you know the period, find the noble gas in the previous period to start the condensed electron configuration.	The noble gas that starts the condensed electron configuration is at the end of group 3: argon, Ar.
Complete the electron configuration by filling orbitals with the valence electrons according to the guidelines.	Two of the ten valence electrons fill the 4*s* orbital leaving 8 for the *d* orbitals. Therefore, the condensed electron configuration for nickel is $[Ar]4s^2 3d^8$.

b. The element in Period 6 with 3 valence electrons.

Plan Your Strategy	Act on Your Strategy
For all elements other than *f*-block elements, the number of valence electrons corresponds to the group number. The principle quantum number of the *s* orbital corresponds to the period number.	Since the element is in Period 6, it can have *f*-block electrons. The element has 3 valence electrons, indicating that the 6*s* orbital is filled.

Plan Your Strategy	Act on Your Strategy
Determine the block and period numbers and, using a periodic table, find the element.	Analysis of the blocks in the skeleton periodic table in Figure 3.20 on page 187 of the student textbook shows that the third electron in Periods 6 and 7 enter the (n - 1)d orbital, before starting to fill the f orbitals.
When you know the period, find the noble gas in the previous period to start the condensed electron configuration.	When you look for the element in Period 6 that has three valence electrons, you will find that it is lanthanum, La. The noble gas at the end of Period 5 is xenon, Xe.
Complete the electron configuration by filling orbitals with the valence electrons according to the guidelines.	The condensed electron configuration for lanthanum is [Xe]$6s^25d^1$.

Check Your Solution

Consulting a periodic table that includes electron configurations will confirm the electron configurations.