Name: Jurnee Mae Date: _____

Student Exploration: Electron Configuration

Vocabulary: atomic number, atomic radius, Aufbau principle, chemical family, diagonal rule, electron configuration, Hund's rule, orbital, Pauli exclusion principle, period, shell, spin, subshell

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. Elvis Perkins, a rather shy fellow, is getting on the bus shown at right. Which seat do you think he will probably sit in? Mark this seat with an "E."

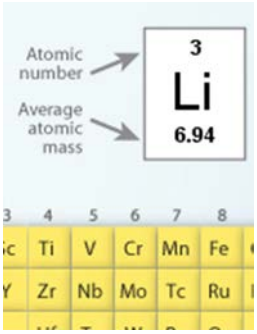
2. Marta Warren gets on the bus after Elvis. She is tired after a long day at work. Where do you think she will sit? Mark this seat with an "M."

3. In your experience, do strangers getting on a bus like to sit with other people if there is an empty seat available? No.

Gizmo Warm-up

Just like passengers getting on a bus, electrons orbit the nuclei of atoms in particular patterns. You will discover these patterns (and how electrons sometimes act like passengers boarding a bus) with the *Electron Configuration* Gizmo™.

To begin, check that **Lithium** is selected on the PERIODIC TABLE tab.



1. The **atomic number** is equal to the number of protons in an atom.

   How many protons are in a lithium atom? 3

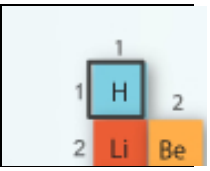
2. A neutral atom has the same number of electrons and protons.

   How many electrons are in a neutral lithium atom? 3

3. Select the ELECTRON CONFIGURATION tab. Click twice in the **1s** box at upper left and once in the **2s** box. Observe the atom model on the right.

   A. What do you see? A nucleous with balls orbiting it.

   B. Click **Check**. Is this **electron configuration** correct? YES!!!

Activity A: **Small atoms**	Get the Gizmo ready: • On the PERIODIC TABLE tab, select **H** (hydrogen). • Select the ELECTRON CONFIGURATION tab. • Click **Reset**.	

Introduction: Electrons are arranged in **orbitals**, **subshells**, and **shells**. These levels of organization are shown by the boxes of the Gizmo. Each box represents an orbital. The subshells are labeled with letters (*s*, *p*, *d*, and *f*) and the shells are labeled with numbers.

Question: How are electrons arranged in elements with atomic numbers 1 through 10?

1. Infer: Based on its atomic number, how many electrons does a hydrogen atom have? 1

2. Arrange: The **Aufbau principle** states that electrons occupy the lowest-energy orbital. Click once in the **1s** box to add an electron to the only orbital in the *s* subshell of the first shell.

   Click **Check**. What is the electron configuration of hydrogen? 1s1

3. Arrange: Click **Next element** to select helium. Add another electron to the **1s** orbital. The arrows represent the **spin** of the electron. What do you notice about the arrows?

   One faces upward and one faces downward.

   The **Pauli exclusion principle** states that electrons sharing an orbital have opposite spins.

4. Check your work: Click **Check**. What is the electron configuration of helium? 1s

5. Arrange: Click **Next element** and create electron configurations for lithium, beryllium, and boron. Click **Check** to check your work, and then list each configuration below:

   Lithium: 1s2 2s1 Beryllium: 1s2 2s2 Boron: 1s2 2s2 2p1

6. Arrange: Click **Next element** to select carbon. Add a second electron to the first **2p** orbital.

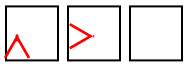
   Click **Check**. What feedback is given? that it is in the incorrect energy level

7. Rearrange: **Hund's rule** states that electrons will occupy an empty orbital when it is available in that subshell. Rearrange the electrons within the **2p** subshell and click **Check**.

   Is the configuration correct now? Yes

   Show the correct configuration in the boxes at right:

   1s 

   2s  **2p** 

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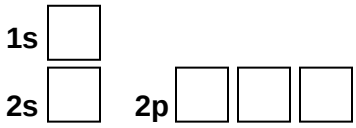
Activity A (continued from previous page)

8. Compare: How are the electrons in the **2p** subshell similar to passengers getting on a bus?

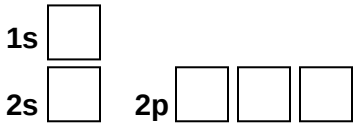
The amount of people on a seat and were there options are once seats become full.

9. Practice: In the spaces below, write electron configurations for the next four elements: nitrogen, oxygen, fluorine, and neon. When you are finished, use the Gizmo to check your work. Correct any improper configurations.

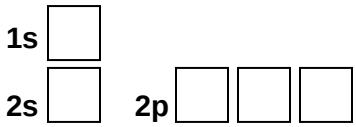
Nitrogen configuration: 1s2 2s2 2p3



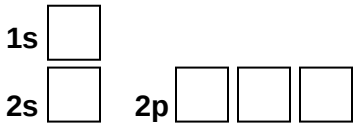
Oxygen configuration: 1s2 2s2 2p4



Fluorine configuration: 1s2 2s2 2p5



Neon configuration: 1s2 2s2 2p6



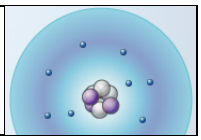
10. Apply: Atoms are most stable when their outermost shell is full. If their outermost shell is not full, atoms tend to gain, lose, or share electrons until the shell fills up. While doing this, atoms react and form chemical bonds with other atoms.

Based on this, what can you infer about the reactivity of helium and neon? _____

Neon is stronger than Helium and Helium loses electrons easier than Neon.

11. Think and discuss: Select the PERIODIC TABLE tab, and look at the second row, or **period**, of the table. How does this row reflect the subshells of the second shell?

It moves on to a different group of subshells.

Activity B: **Atomic radii**	Get the Gizmo ready: • On the PERIODIC TABLE tab, select **Na** (sodium). • Select the ELECTRON CONFIGURATION tab.	

Question: How do the radii of atoms change across a period of the periodic table?

1. Predict: Positively charged protons in the nucleus of an atom are attracted to negatively charged electrons.

   How do you think the **atomic radii** will change as electrons are added to a shell?

   _____

2. Arrange: Create a proper electron configuration for sodium. After clicking **Check**, note the **Electron configuration** and the **Atomic radius** now listed at right.

   Sodium electron configuration: _____ Atomic radius: _____

3. Compare: Click **Next element**, and then add an electron to the magnesium atom. Click check, and record the electron configuration and atomic radius below.

   Magnesium electron configuration: _____ Atomic radius: _____

4. Gather data: Create electron configurations for the next six elements. Record the electron configuration and atomic radius of each. (Note: The symbol for picometer is *pm*.)

Element	Number of electrons	Electron configuration	Atomic radius (pm)
Aluminum			
Silicon			
Phosphorus			
Sulfur			
Chlorine			
Argon			

5. Analyze: How does the atomic radius change across a period of the periodic table?

   _____

   _____

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Activity B (continued from previous page)

6. Interpret: Select the ATOMIC RADIUS tab. What do you notice? _____

   _____

7. Predict: On the ATOMIC RADIUS tab click **Clear**. Select the PERIODIC TABLE tab. Elements in the same column of the periodic table are called **chemical families**, or groups.

   How do you think the size of atoms will change from top to bottom within a chemical family?

   _____

8. Test: Hydrogen, lithium, and sodium are all in the same chemical family. Use the Gizmo to find the atomic radius of each, and list them below.

   Hydrogen radius: _____ Lithium radius: _____ Sodium radius: _____

9. Analyze: How does the atomic radius change as you go from the top to the bottom of a chemical family? _____

10. Challenge: Think about the factors that control atomic radius and the patterns you've seen.

    A. Why does the atomic radius decrease as electrons are added to a shell? _____

       _____

       _____

    B. Why does the atomic radius increase as you go from the top to the bottom of a chemical family? _____

       _____

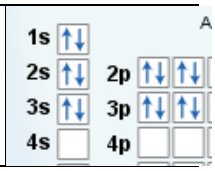
       _____

11. Think and discuss: Compare the electron configurations of hydrogen, lithium, and sodium. Why do you think these elements are grouped in the same family?

    _____

    _____

    _____

Activity C: **The diagonal rule**	Get the Gizmo ready: • On the PERIODIC TABLE tab, select **Ar** (argon). • Select the ELECTRON CONFIGURATION tab. • Turn on **Show number of electrons**.	

Introduction: Beyond argon, it is a bit tricky to determine which subshell gets filled next. There are several rules that scientists use to determine the electron configurations of larger atoms.

Question: How are the electron configurations of elements beyond argon determined?

1. Arrange: Create the correct electron configuration for argon. Then, click **Next element** to get to potassium (K). Click once in the first **3d** orbital, and then click **Check**.

   What feedback is given? _____

2. Rearrange: As it happens, the 4*s* subshell is a lower-energy subshell than 3*d*, so it is filled first. Remove the electron from the **3d** orbital and place it in the **4s** orbital. Click **Check**. (Note: For simplicity, all but the outer shell electrons will disappear on the **Bohr Model**.)

   Is this configuration correct? _____ What is the configuration? _____

3. Arrange: Click **Next element** and add an electron for calcium. Click **Check**.

   What is the electron configuration for calcium? _____

4. Arrange: Click **Next element** and add an electron for scandium. Try different orbitals until you find the right one.

   What is the electron configuration for scandium? _____

5. Observe: Scandium is the first element to contain electrons in the *d* subshell. How many orbitals does the *d* subshell have, and how many electrons can fit in the *d* subshell?

   _____

6. Infer: Select the PERIODIC TABLE tab. The middle section of the table is a chemical family called the transition metals. Why do you think this section is ten columns wide?

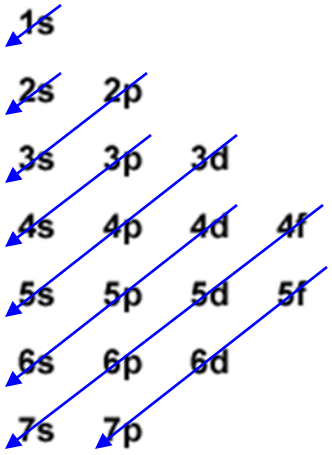
   _____

   _____

   _____

(Activity C continued on next page)

Activity C (continued from previous page)



7. Make a rule: The **diagonal rule** explains which subshell will be filled next. To follow the diagonal rule, move down along an arrow until you reach the end of the arrow. Then move to the start of the next arrow to the right.

   A. Which subshell is filled after 4*p*? _____

   B. Which subshell is filled after 6*s*? _____

   C. Which subshell is filled after 5*d*? _____

8. Practice: Determine the electron configurations of the following elements. Use the Gizmo to check your work. (Note: In some cases, the diagonal rule doesn't work perfectly. If you submit a theoretically correct configuration, the Gizmo will give you the actual configuration.)

Element	Atomic number	Electron configuration
Cobalt (Co)	27	_____
Germanium (Ge)	32	_____
Yttrium (Y)	39	_____
Neodymium (Nd)	60	_____
		_____
Gold (Au)	79	_____
		_____

9. Infer: Select the PERIODIC TABLE tab. Earlier you saw that the transition metals represent the filling of the *d* subshells. Now locate the purple lanthanides and actinides on the bottom rows of the periodic table.

   A. How many elements are in the in the lanthanides series? _____

   B. Which subshell is represented by the lanthanides family? _____

   C. Which subshell is represented by the actinides family? _____

   D. In general, how is the shape of the periodic table related to electron configurations? (If necessary, continue your answer on another sheet of paper.)

   _____

   _____