3-D Aufbau Diagram

Electron Configuration

Introduction

Construct a visual diagram that can help explain and model the appropriate filling order for electrons in electronic configurations.

Concepts

- Aufbau principle
- Electron configurations
- Orbital filling diagrams
- Hund's rule
- Pauli exclusion principle

Materials

Cups, clear small (condiment or medicine cups), 30

Hot glue gun

Marbles or other small objects, two different colors

Poster board, large

Safety Precautions

Exercise caution when handling the hot glue gun. This activity is considered non-hazardous.

Preparation

1. Lay out the cups to match the attached diagram.
2. Glue each cup to the board so that it will hold the marbles when displayed.
3. Label each cup with the appropriate orbital designation. ("2s," "3p," "5d," etc.) This can be done either directly on the cup or on the board.
4. When the board is completed, use two differently-colored objects to start filling orbitals (one color for each spin direction).

Disposal

All materials may be saved and stored for future use.

Tips

- Use this display to show the electron configuration for various elements, such as hydrogen, helium, oxygen or nitrogen.
- This display provides a nice visual display of an orbital filling diagram. Students could also make this on their own as a project (either in class, at home, or for extra credit), which would help them better remember and understand the differences in energy between the orbitals.
- Using an analogy of a bus is helpful for relating Hund's Rule: if you enter a bus and don't know anyone on it, you will pick a seat that is completely empty rather than one that already has a person in it. From an energy standpoint, pairing electrons in the same orbital requires additional energy due to the natural repulsion of the electrons; it is energetically favorable for electrons to occupy empty orbitals over having to pair up with another electron in a half-filled orbital.
- A total of 51 small, clear cups will be required to include the f-orbitals in the 3-D display.

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Discussion

Electron configurations are the ways electrons are situated around the nuclei of atoms. There are three basic rules to follow when determining the electron configurations of atoms—the aufbau principle, the Pauli exclusion principle and Hund's rule.

The *aufbau principle* states that electrons enter orbitals of the lowest energy first. The *s*-orbital is always the lowest energy sublevel. Beyond the second energy level, the filling of atomic orbitals does not follow a simple pattern. For example, the 5*s* orbital is of lower energy than the 4*d* orbital (see Figure 3 for a complete pattern of orbital levels).

The *Pauli exclusion principle* states that an atomic orbital may contain a maximum of two electrons and that in order to occupy the same orbital, the two electrons must have opposite spins. A vertical arrow represents an electron and its direction of spin.

Hund's rule states that when electrons occupy orbitals of equal energy, an electron enters each orbital until all of the orbitals contain one electron with parallel spins. For example, five electrons of the same spin would occupy five orbitals of the same energy level as shown in Figure 1.

Figure 1.

As more electrons are added to the orbitals in this energy level, they enter with spins opposite to those of the first electrons in the orbitals. Two electrons occupying the same orbital are said to have paired spins. See Figure 2.

Figure 2.

A sample electron order filling diagram would look as follows in Figure 3.

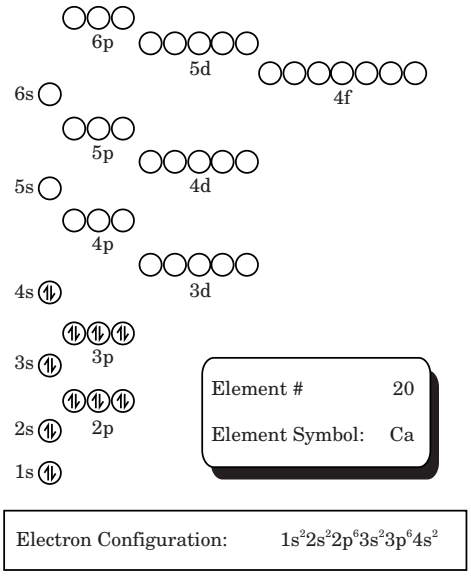


Figure 3. Sample electron order of filling for calcium

Valence electron configurations are also presented in this diagram. Valence electrons are the electrons in the highest occupied energy level of an elements. For example, sodium has one valence electron in the 3s orbital. The number of valence electrons largely determines the properties of an element. The valence number of an element is also related to the group number in the periodic table. For example, all elements in group IIA (berllyium, magnesium, calcium, etc.) contain two valence electrons.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure of atoms, structure and properties of matter, chemical reactions, interactions of energy and matter

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *3-D Aufbau Diagram* activity, presented by Jamie Benigna, is available in *Electron Configuration*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

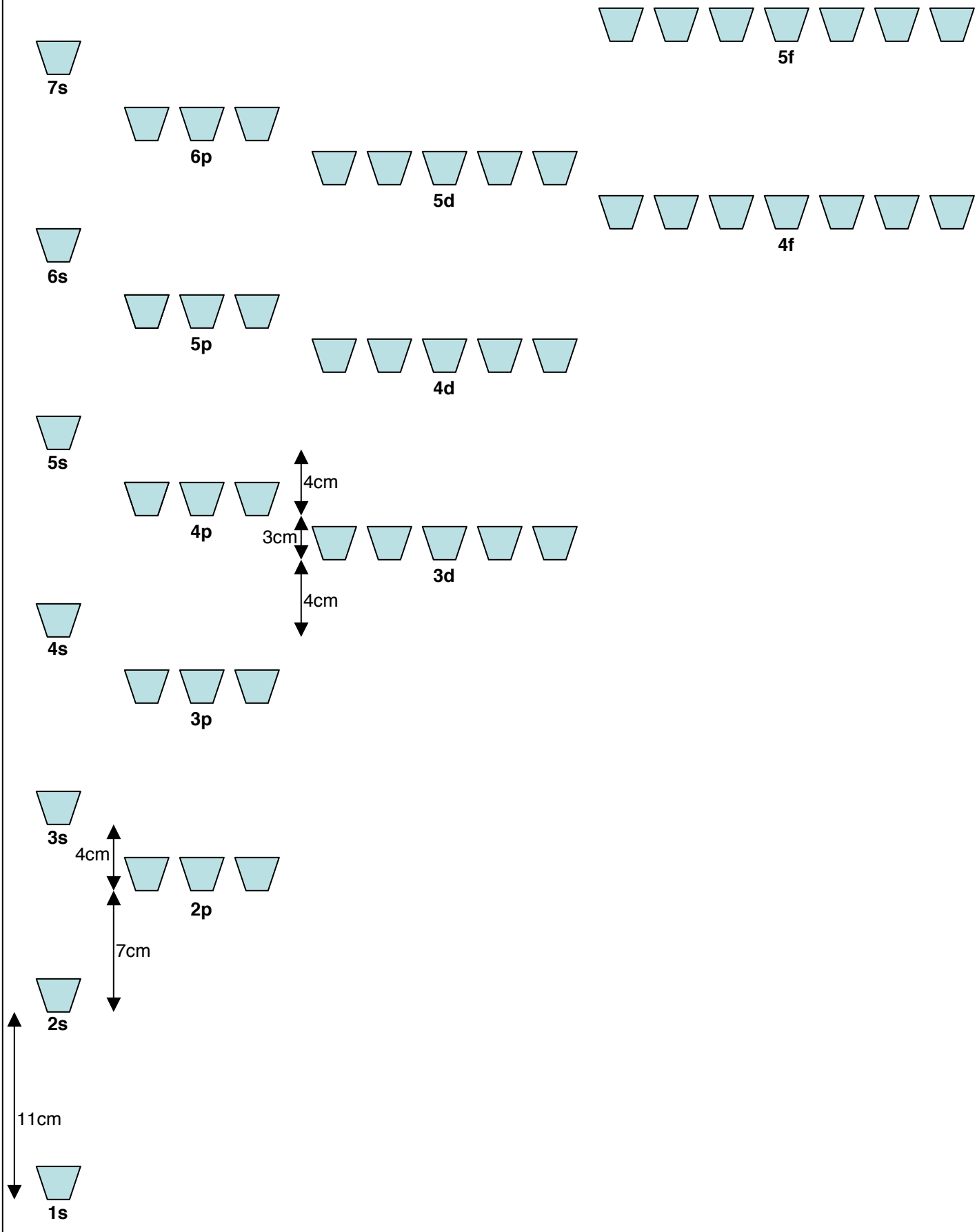
Materials for *3-D Aufbau Diagram* are available from Flinn Scientific, Inc.

A related activity, *Electron Configuration Bingo*, is available from Flinn Scientific. Materials to perform both activities may be purchased separately.

Catalog No.	Description
AP6379	Electron Configuration Bingo
AP5442	Polypropylene Cups, pkg. 100
AP2279	Balls, Styrofoam®, 1" diameter, pkg. 16
AP9011	Glue gun
AP9012	Glue sticks, pkg. 24

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

3-D Aufbau Diagram *continued*



3-D Aufbau Diagram *continued*