

Lesson 1-2: Quantum Mechanical Model of the Atom	
Curriculum Expectations	<p>C2.1: use appropriate terminology related to structure and properties of matter, including, but not limited to: <i>orbital, emission spectrum, energy level, photon, and dipole</i> [C]</p> <p>C2.2 use the Pauli exclusion principle, Hund's rule, and the Aufbau principle to write electron configurations for a variety of elements in the periodic table [AI, C]</p> <p>C3.2 describe the electron configurations of a variety of elements in the periodic table, using the concept of energy levels in shells and subshells, as well as the Pauli exclusion principle, Hund's rule, and the Aufbau principle</p>
Learning Goals	<p>By the end of this lesson you will:</p> <ul style="list-style-type: none"> • Understand the limitations of the Bohr model of the atom. • Know the 4 quantum numbers and the characteristics they describe • Understand the Pauli Exclusion Principle
Success Criteria	<p>Success Criteria:</p> <p>I know I have achieved the learning goals when I:</p> <ul style="list-style-type: none"> • can connect quantum number values to the characteristics they describe • can describe atomic orbitals in terms of their energy, shape, orientation and electron spin
Teacher Prep	<ul style="list-style-type: none"> • Check to see that rates of reaction simulator works on your computer. • Print out Gridlock activity if not doing it on the projector as a class. • Print out handout if you want students to fill it out as they progress through the lesson.

Minds On
<p>Goal: To introduce the concept of quantum numbers by having students describe other characteristics using numbers.</p> <p>1. <u>Class Discussion</u></p>

- Begin the lesson by having the class choose different numbers and letters to describe characteristics & locations of humans (i.e. Hair colour: red hair = 1, black hair = 2, blonde hair = 3; Eye colour: blue = Bl, brown = Br; height: below 4' = -1, between 4'-5' = 0; above 5' = +1; live in a house = s, apartment = a, etc) do this for several characteristics.
- Next have students describe themselves using this system. (e.g. a blond haired, blue eyed person taller than 5' would be described as: 3, Bl, +1.
- Next pull up pictures of famous people (athletes, movie stars, etc) and have different students describe them using the numbering system.

Follow up by introducing the lesson title and explain that quantum numbers are a system that scientists use to describe the location and characteristics of an electron in an atom.

Action

1. 1-2: Handout

Have students complete the handout as they work their way through the lesson *or* you can assign the handout as homework to completed after class and taken up in the next session.

2. 1-2A: Shells & Subshells

Watch the introductory video as a class and explain that the video will summarize the important information they will learn in the next series of activities.

Have students read through section A. Shells & Subshells on their own. Circulate around the class as they are reading to address any immediate questions or misconceptions.

Take up the material as a class, showing the diagrams on a projector.

Points of emphasis:

- n represents a shell, which is associated with a specific amount of energy.
- Higher n -values indicate higher energy.
- These shells are what produce the different lines in the emission spectrum.
- Within a shell there can be multiple, more distinct regions called orbitals.
- Orbitals describe regions in space, within a shell, around the atom where electrons can be found.
- Orbital within a shell have their own associated energies.

3. **Shells & Subshells Group Activity:** Groups or Whole class. Click on the link for the online version of the gridlocks activity or if in groups or individually, give printouts for the students to complete. Explain the rules.

Teacher information:

Gridlock Puzzles are designed to do 3 major things:

1. They give the students a problem solving context for the activity – students like solving problems and there is a sense of satisfaction in completing the gridlock. There can be an aspect of competition as well: who solved the most, who was quickest or who made the least mistakes. In the online versions the students are trying to beat the clock.
2. The students need to engage with the factual information the gridlock is based on. In order to solve the puzzle they need to recall the relationships between the data established in the first part of the activity. For example they need to recall that 3 electron pairs gives trigonal planar geometry or that sulfuric acid forms sulfate salts. Whilst they are solving the gridlocks they should find themselves referring to the initial data repeatedly so much so that they recall a fair bit of it by the end.
3. It develops some important thinking skills. The students have to survey the data given in the gridlock to find which squares can initially be filled in. They cannot simply choose a square at random and fill it in because there may not be enough information yet in the grid to narrow down the options to one possible answer. This thinking skill is sadly missing in the students who, given a titration calculation want to straight multiply a concentration by a volume to give the moles of the reactant asks for despite not having all the relevant information yet. Gridlocks also encourage logical reasoning e.g. 'it has to be x because it can't be w, y or z'.

How they might be used:

Gridlocks are suitable for an episode in a lesson or homework. They are designed to be follow up activities rather than an introduction to a topic. The students should have met at least some of the data the gridlocks are based on. The online gridlocks could be tackled by students working individually or a class using a projector. The paper based gridlocks are easy to set and readily peer or self assessed. Some gridlocks go beyond specifications and could be used as extension activities.

4. 1-2B: Quantum Numbers Part 1 & 2.

Begin by explain that quantum numbers are used as a system to describe the location and characteristics of an electron in an orbital. Similar to the system devised in the minds on activity.

Have students read through sections A, B & C on their own to briefly introduce the topics.

Use the slides for lesson 2 to guide students through the explanation for the first 2 quantum numbers. Stop often to address any confusion or misconceptions. Use the images of orbitals/subshells to help emphasize important points.

Next have students read section D. on their own and follow up by guiding them through the topic using the presentation slides.

Have students complete the table on the handout. When you are finished with the lesson you can have students play a quick game to test their understanding of what shells & subshells are and which quantum numbers correspond to what orbital shapes and names.

1-2C: Quantum Numbers Part 2.

Review the first 2 quantum numbers before introducing the next 2. Emphasize again that quantum numbers can be used to describe the position and characteristics of an electron in an atom.

Have students read through section A & B on their own followed by a presentation using the slides for the lesson. Emphasize how an orbital can have different orientations and how this explains how for certain orbitals, there can be multiple of that orbital type within a shell depending on the orientation.

Also important to emphasize how the 2ndary quantum number gives us information on how to interpret the magnetic quantum number.

Have students complete their own version of the table that summarizes the relevant information about the first 3 quantum numbers. You can turn this into a quiz game to consolidate at the end of a class.

Have students read section C on their own, then take up the information as a class. Point of emphasis here is the Pauli exclusion principle. Important to note to students that the Pauli exclusion principle relates to electrons in the same atom. Therefore, 2 electrons in different atoms could have the same 4 quantum numbers.

Review: Watch the video at the bottom of the activity to consolidate information.

Consolidation

- 1. 1-2E: Quiz** Students complete the quiz individually on their own in class or at home. Once all students have completed the quiz, take up the answers as a class.
- 2. 1-2F: Practice Worksheet.** To be completed individually, in class or at home. Take up the answers together.
- 3. Exit Card**
 - Print out the following on an exit card and hand to students as they leave to be brought in the following class and discussed.

Exit Card Question:

“Create a table to compare and contrast energy levels in the Bohr model of the atom and in the quantum mechanical model of the atom “