Unit 2: Atomic Structure and Bonding

Chapter 5: The Periodic Table and Chemical Trends

# Lesson 2: Working with Scientific Notation and Units

1. Big Idea:  
Scientific notation and units help scientists represent and work with very large or very small numbers efficiently, making calculations easier and more accurate in scientific contexts.  
  
 2. Essential Questions:  
- How does scientific notation simplify the representation of extremely large and small numbers in science?  
   
**Answer**: Scientific notation allows us to express very large or very small numbers in a compact form, which saves space and reduces the chance of error when writing or calculating with them. It simplifies working with numbers like the size of atoms or the distance between planets, making them easier to manage.  
  
 3. Phenomenon-Based Learning:  
 Phenomenon Connection:   
**Unit Phenomenon**: In northern countries, road salt helps melt ice and snow during the winter. The salt appears to make the ice vanish, but why doesn't it affect metal street signs or lampposts in the same way?   
  
**Chapter Phenomenon:** Different types of salts—sodium chloride, magnesium chloride, and calcium chloride—are used to clear roads. How are these salts different if they all contain chloride? Why do some salts work better or behave differently in cold temperatures?  
  
  
  
 4. Vocabulary:  
- **Ampere**: The base unit of electric current in the International System of Units (SI).  
- **Base Units**: Fundamental units in the SI system used to define all other units (e.g., meter, kilogram, second).  
- **Candela**: The SI base unit of luminous intensity.  
- **Dimensional Analysis**: A mathematical technique used to convert one unit of measurement to another by using conversion factors.  
- **Meter**: The SI base unit for length.  
- **Kelvin**: The SI base unit for temperature.  
- **Kilogram**: The SI base unit for mass.  
- **Mole**: The SI base unit for the amount of substance.  
- **Scientific Notation**: A way of writing large or small numbers using powers of ten.  
- **Second**: The SI base unit for time.  
- **SI Units**: The International System of Units, the standard set of units used by scientists worldwide.  
  
  
  
 5. SMART Objectives:  
By the end of this lesson, students will be able to:  
1. Express numbers in scientific notation, converting between standard form and scientific notation.  
2. Perform dimensional analysis to convert between different units of measurement.  
3. Develop a method to convert between different units using dimensional analysis, ensuring accuracy in scientific calculations.  
  
  
  
 6. Engage (Ignite):  
**Phenomenon-Related Question:**   
Imagine you live in a country where it snows every winter. You see workers spreading salt on the roads to melt the ice, but the salt doesn’t seem to affect the metal street signs. Why is this happening? What role might temperature, or the type of salt, play in this phenomenon?  
  
**Hands-On Experiment:**   
**Objective**: Use dimensional analysis to calculate how much salt is needed to cover a road 1 kilometer long with a layer of salt 0.5 centimeters thick.   
  
**Materials**:  
- Table salt  
- Measuring spoons  
- Ruler or meter stick  
- Calculator  
  
**Procedure**:   
1. Measure out 1 tablespoon of salt and weigh it using a scale (in grams).  
2. Measure the area of a small section of a road model (or tabletop) in square centimeters.  
3. Calculate how much salt is needed to cover the entire road surface in a consistent layer (0.5 cm thick).  
4. Use dimensional analysis to convert your measurements from centimeters to meters and kilometers.  
  
**Follow-Up Questions**:  
1. How does converting units help you in this experiment?  
2. Why is it important to use the correct units when measuring and calculating?  
3. Can you explain how scientific notation might help in calculating large numbers, like the amount of salt needed for an entire city?  
  
  
  
 7. Pre-Explore (Direct Instruction):  
In science, we deal with numbers that are either very large (like the distance between stars) or very small (like the size of atoms). Writing these numbers in their full form can be difficult and prone to mistakes. This is where scientific notation comes in.  
  
Scientific notation expresses numbers as a product of two parts:  
- A number between 1 and 10.  
- A power of 10.  
  
For example:  
- The number 300,000,000 can be written as \(3.0 \times 10^8\).  
- The number 0.000000032 can be written as \(3.2 \times 10^{-8}\).  
  
This makes it easier to handle large and small numbers in calculations.  
  
Now, when working with measurements, scientists use a specific system of units called the **International System of Units (SI Units)**. The SI system includes base units like the meter (for distance), kilogram (for mass), and second (for time). Converting between different units, like from meters to kilometers or seconds to minutes, requires **dimensional analysis**.  
  
**Dimensional analysis** is a method that helps us convert one unit into another by multiplying by conversion factors. For example, if you need to convert 5 kilometers to meters, you can use the conversion factor 1km=1000m.

**Interactive Example**:   
Convert 5 kilometers into meters using dimensional analysis.   
 5km×1km1000m​=5000m  
  
 8. Evaluate (Progress Check) - Pre-Explore:  
1. Convert 1.5 kilometers into meters using dimensional analysis.  
2. Why is scientific notation useful when working with very small numbers, such as the diameter of an atom?  
3. Convert 0.0032 seconds into scientific notation.  
  
  
  
 9. Explain (Lightbulb Moment):  
**Scientific Notation**:   
Let’s dive deeper into why scientific notation is so useful. Imagine measuring the distance between planets. The distance between Earth and the Sun is about 150,000,000 kilometers. Instead of writing all those zeros, we can express the number as \(1.5 \times 10^8\) kilometers.  
  
Similarly, the size of an atom is incredibly small—about 0.0000000001 meters. Writing this as \(1 \times 10^{-10}\) meters is much easier and clearer.  
  
 Steps to Convert to Scientific Notation:  
1. Move the decimal point in the number so that you have a number between 1 and 10.  
2. Count how many places you moved the decimal point. This will be your exponent.  
 - If you moved the decimal to the left, the exponent is positive.  
 - If you moved the decimal to the right, the exponent is negative.  
  
**Example Problem:**   
Convert 0.00056 to scientific notation.   
**Solution**:   
Move the decimal 4 places to the right to get \(5.6 \times 10^{-4}\).  
  
**Progress Check**:   
Convert 67,000,000 into scientific notation.  
  
  
  
**Dimensional Analysis**:   
Now, let's talk about converting units. We often need to convert between different units of measurement in science. For example, you may need to convert kilometers to meters, kilograms to grams, or seconds to minutes.  
  
**Steps to Perform Dimensional Analysis:**   
1. Start with the value and unit you are converting from.  
2. Multiply by a conversion factor (a fraction) that has the unit you want to end up with on top, and the unit you are converting from on the bottom.  
3. Cancel out the units and calculate the result.  
  
**Example Problem**:   
Convert 4.5 kilometers to meters.   
Solution:   
 4.5km×1km1000m​=4500m  
**Progress Check**:   
Convert 2.75 hours to seconds.  
  
  
  
 10. Expansion of Concepts:  
Let’s revisit the phenomenon we discussed earlier: road salt melting ice in cold weather. Does scientific notation help in explaining how much road salt is used? Yes! For example, a city may need to spread several tons of salt across many kilometers of road. Instead of writing out all the zeros, scientific notation allows us to simplify the calculations.  
  
Additionally, dimensional analysis helps ensure we’re using the correct units. If a scientist needs to know how much salt to cover a road, they will likely use dimensional analysis to convert between units like centimeters (for thickness of salt) and kilometers (for length of the road).  
  
By combining these two tools—scientific notation and dimensional analysis—scientists can perform accurate calculations efficiently, helping them solve real-world problems like making roads safer in winter.  
  
  
  
 Wrap-Up:  
By the end of this lesson, you should understand how to use scientific notation to simplify numbers and how to perform dimensional analysis to convert between units. These skills are essential in science, where we often deal with very large or very small quantities, and need to ensure our measurements are precise.  
  
  
  
 Additional Progress Check:  
1. Convert 0.0000789 into scientific notation.  
2. Perform dimensional analysis to convert 15 minutes into seconds.  
3. Why is it important to use scientific notation and dimensional analysis in science?  
  
Sure! Here's an organized response according to your specified sections.  
  
  
  
 10. Evaluate (Progress Check)  
  
**Question 1 (DOK 1 - Recall):**   
What is the atomic number of an element, and where can you find it on the periodic table?   
**Answer:**   
The atomic number of an element is the number of protons in the nucleus of an atom. You can find it above the element symbol on the periodic table.  
  
  
  
**Question 2 (DOK 2 - Skill/Concept):**   
Explain how the atomic structure of an element changes as you move across a period in the periodic table.   
**Answer:**   
As you move across a period, the number of protons and electrons increases. This also means that the number of electrons in the outer shell increases, which changes the chemical properties of the element.  
  
  
  
**Question 3 (DOK 3 - Strategic Thinking):**   
How does the arrangement of elements in the periodic table help predict the properties of elements?   
**Answer:**The periodic table is organized by increasing atomic number and grouped by properties. Elements in the same group have similar chemical properties due to having the same number of electrons in their outer shell. This makes it easier to predict how elements will react with others.  
  
  
  
 11. Elaborate (Power Up)  
  
**Mini-task (DOK 2):**   
Compare and contrast metals and non-metals in terms of their physical and chemical properties.   
**Answer**:   
Metals are generally shiny, malleable, and good conductors of heat and electricity, while non-metals are often dull, brittle, and poor conductors. Chemically, metals tend to lose electrons to form positive ions, while non-metals tend to gain electrons to form negative ions.  
  
  
  
**Open-ended question (DOK 3):**   
Imagine you are given an unknown element. How would you determine whether it is a metal, non-metal, or metalloid using its properties?   
**Answer:**   
You could observe its physical properties (such as shine, malleability, and conductivity). If it's shiny and conducts electricity, it is likely a metal. If it is dull and brittle, it might be a non-metal. If it shows characteristics of both, it could be a metalloid. You could also test its chemical reactivity to understand whether it loses or gains electrons in reactions.  
  
  
  
 12. Final Evaluation  
  
**Debate Question (DOK 3 - Extended Thinking):**"Should we prioritize the development of synthetic elements even though they may be unstable?"   
**Discussion Points:**   
- **Pro**: Developing synthetic elements allows us to explore the boundaries of chemistry and could lead to new materials or energy sources.   
- **Con**: Synthetic elements are often unstable and expensive to produce, raising questions about their practical usefulness and the safety of working with them.  
  
  
  
**Assessment Questions:**  
**Multiple Choice:**  
1. **Which subatomic particle determines the chemical properties of an element?**   
 - a) Protons   
 - b) Neutrons   
 - c) Electrons   
 - d) Nucleus   
 **Answer: c) Electrons** **Explanation:** The chemical properties of an element are determined by the arrangement and behavior of its electrons, especially the outermost (valence) electrons.  
  
2. **What happens to the atomic radius as you move down a group in the periodic table?** - a) It increases   
 - b) It decreases   
 - c) It stays the same   
 - d) It fluctuates   
 **Answer: a) It increases**   
 **Explanation:** As you move down a group, more electron shells are added, increasing the size of the atom.  
  
3. **Which of the following is a noble gas?**   
 - a) Oxygen   
 - b) Nitrogen   
 - c) Argon   
 - d) Hydrogen   
 **Answer: c) Argon**   
 **Explanation:** Noble gases are found in Group 18 of the periodic table, and Argon is one of them.  
  
4. **Which element is most likely to form a positive ion?**   
 - a) Fluorine   
 - b) Sodium   
 - c) Nitrogen   
 - d) Oxygen   
 **Answer: b) Sodium**   
 **Explanation:** Sodium is a metal and tends to lose one electron to form a positive ion.  
  
  
  
**Long Answer:**  
1. **Explain how Dmitri Mendeleev organized the first periodic table and how it's different from the modern periodic table**.   
 **Answer**:   
 Mendeleev organized the elements by atomic mass and grouped them by similar properties. He even left spaces for elements that had not yet been discovered. The modern periodic table is organized by atomic number instead of atomic mass, which resolves some issues Mendeleev's table had, such as elements not fitting perfectly into groups based on mass alone.  
  
2. **Describe how the periodic trend of electronegativity changes across a period and down a group.**   
 **Answer:**   
 Electronegativity increases across a period because atoms have more protons and are better at attracting electrons. It decreases down a group because the added electron shells make it harder for the nucleus to attract electrons.  
  
3. **How do valence electrons affect the chemical bonding of an element? Provide an example.   
 Answer:**   
 Valence electrons determine how an element bonds with others. For example, sodium has one valence electron, which it easily loses to form an ionic bond with chlorine, which needs one electron to complete its outer shell.  
  
4. **Discuss the role of the periodic table in predicting the behavior of elements in chemical reactions.   
 Answer:**   
 The periodic table helps predict behavior because elements in the same group have similar properties due to their valence electron configuration. For example, alkali metals (Group 1) are highly reactive with water because they all have one valence electron that they readily lose in reactions.  
  
  
  
 13. Extend (Beyond the Lesson)  
  
**Additional Tasks or Readings**:  
  
1. **Task:** Research a synthetic element, such as Californium or Einsteinium, and write a report on its uses and challenges in handling it.   
 **Objective:** To understand the real-world applications of rare elements and the difficulties scientists face when working with unstable elements.  
  
2. **Reading**: Read about the discovery of noble gases and how their "inert" nature made their discovery unique in the history of chemistry.   
 **Objective:** To explore how scientists sometimes have to rethink what they know when new discoveries challenge existing theories.  
  
3. **Real-World Application:**   
 Investigate how the periodic table is used in industries such as electronics or pharmaceuticals. For example, how do engineers use the properties of metals and non-metals in designing smartphones or batteries?   
 **Objective:** To see how the properties of elements are applied in everyday life, such as in technology or medicine.  
  
**Opportunities for Spaced Practice:**   
1. **Weekly Review Sessions:**   
 Create a "Periodic Table Bingo" game where students match element properties to their correct positions on the table.   
 Objective: To reinforce the understanding of periodic trends through a fun, low-stakes activity.  
  
2. **Cumulative Quizzes:** Short quizzes every two weeks to revisit topics covered in earlier lessons, ensuring that students retain key ideas like atomic structure, periodic trends, and chemical bonding.  
  
  
  
This structure ensures students can understand the core ideas, think more deeply, and apply the information to new and real-life problems.