**Standard**

CHEM1.PS2.1– Draw, identify, and contrast graphical representations of chemical bonds (ionic, covalent, and metallic) based on chemical formulas. Construct and communicate explanations to show that atoms combine by transferring or sharing electrons.

*Tennessee Academic Standards for Science:* Page 71

**Three-dimensional Learning Performance for Lesson**

*Students will* construct explanations using evidence  *in order to* illustrate the nature of ionic bonding within the Copper (II) chloride compound *highlighting the* structure and properties of ionic compounds.

**Science and Engineering Practice for Lesson**

*Constructing Explanations (for science)*

The goal of this three-dimensional learning performance is for students to construct an explanation for observations they take during the electrolysis of a copper (II) chloride solution. After dissolving the ionic compound copper (II) chloride in water, students will set up a small electrolysis apparatus in a beaker. Students will observe the deposit of copper on the negative electrode and chlorine gas production on the positive electrode. Then, in groups, students will develop an explanation for the formation of ionic compounds based on the ions’ attraction to the opposite charges.

**Disciplinary Core Idea for Lesson**

*Physical Science 1: Matter and Its Interactions*

“The substructure of atoms determines how they combine and rearrange to form all of the world’s substances. Electrical attractions and repulsions between charged particles (i.e. atomic nuclei and electrons) in matter explain the structure of atoms and the forces between atoms that cause them to form molecules (via chemical bonds), which range in size from two to thousands of atoms (e.g. in biological molecules such as proteins). Atoms also combine due to these forces to form extended structures, such as crystals or metals.”

*A Framework for K–12 Science Education:* Page 107

**Crosscutting Concept for Lesson**

*Structure and Function*

When students are able to explain the relationship between the structure of an ionic compound and the characteristic properties of ionic compounds, including the conductivity of ionic compound solutions, they develop a foundation to distinguish between ionic and covalent bonding patterns.

**Prior Knowledge**

This lesson should occur near the middle of the instructional unit.

* Concepts that should be covered before this lesson:
	+ Students should have an underlying knowledge of:
		- Atomic structure
		- The periodic table
		- Ion formation
		- Metals tend to form cations; nonmetals tend to form anions
		- Ionic bonding
		- Chemical formulas of ionic compounds
* This lesson covers portions of standard CHEM1.PS2.1:
	+ Students will illustrate the nature of ionic bonding within the Copper (II) chloride compounds.

It is helpful for students to already know that atoms may gain or lose electrons in order to become more stable (usually forming an octet in the outer energy level) and that metals tend to lose electrons while nonmetals tend to gain electrons. Furthermore, students need to have the ability to represent an ionic compound’s chemical formula based on common ion charges. In addition, it is beneficial for students to have a general knowledge about the solution process, key terms such as solute and solvent, and an elementary understanding of positive-negative Coulombic attraction. As always, it is necessary that students have received adequate instruction on laboratory safety procedures before conducting any lab experiment. **This experiment should be performed in a well-ventilated chemistry lab.**

**Materials**

* ~100-mL beaker (two per group); 50-mL or 150-mL beakers work as well
* 100-mL graduated cylinder
* Distilled water
* Copper (II) chloride, available as Copper (II) chloride dihydrate
* Balance
* Spatula
* Pencil “lead” (0.7 or 0.9 mm diameter), 2 pieces per group
* Scotch tape
* 9-volt batteries (one per group)
* 9-volt battery connector (one per group)
	+ These are available at a local electronics store or online

**Lesson Sequence and Instructional Notes**

1. Student investigation and Observations:

The investigation begins with students comparing solid Copper (II) chloride with a solution which they prepare. Since this is not a quantitative lab experiment, it is not necessary for students to have background knowledge about molarity at this point. An alternative would be to provide students with a prepared solution; however, exposing students to the solid ionic compound helps to reinforce the property that ionic compounds are solid crystals at room temperature.

Students will begin by taking note of some of the physical properties of Copper (II) chloride. These may include the blue color, solid, soluble, grainy crystals. Then, students will prepare a solution of 0.1 M Copper (II) chloride by dissolving 0.5 grams of Copper (II) chloride in 30 mL of distilled water.

Students will prepare the electrolysis apparatus and connect the 9-volt battery. Students should be encouraged to take as many observations as possible as the apparatus runs for 10-15 minutes. While the experiment runs, the teacher may rotate through the room probing students for explanations. Some example questions might include:

* Is the reaction different at the positive and negative electrodes?
* What evidence do you have for this?

Some student responses may include:

“Rust is forming at the electrode.”

“It smells like a swimming pool.”

“I see bubbles.”

2. Gathering Information: How Electrons Flow Through a Circuit



In order to demonstrate the conductivity of various materials, the teacher may prepare a simple conductivity tester with an LED, a 9-volt battery, and a 9-volt battery connector.

The LED may be taped to one wire on the 9-V connector. Then, the teacher do a demonstration testing the conductivity of some example materials such as tap water, distilled water, solid Copper (II) chloride, and a solution of Copper (II) chloride. Ask students to consider the following questions.

* Why does the tap water conduct electricity while the distilled water does not? (Students may answer that there are minerals in the water or fluoride in the water.)
* Why does the solution of Copper (II) chloride conduct electricity while the solid does not?

The teacher may guide the students to the idea that ions are free to move in the solution of Copper (II) chloride. In order to have current electricity, there must be mobile charged particles, whether it is electrons in a metal wire or ions on a solution.

3. Gathering Information: The Solution Process for Ionic Compounds

Then, the teacher may show an online video describing what happens when an ionic compound dissolves in solution. A couple of example videos are located here.

<https://www.youtube.com/watch?v=EBfGcTAJF4o>

<https://www.youtube.com/watch?v=aKGJm6OGJNs>

These videos use sodium chloride as an example; students will apply this concept to Copper (II) chloride as they answer question 3 on the student activity sheet.

At this point, the teacher leads a brief explanation about how a circuit works. This will help students to develop their explanations regarding the movement of copper ions and chloride ions later in the lesson. The teacher should describe how the battery has positive and negative electrodes. At the negative electrode (cathode), there is an abundance of electrons, all repelling each other but trapped on that side. At the positive electrode (anode), there is a net positive charge with the capacity to hold additional electrons.

Using the 9-Volt connector, the red wire connects to the positive electrode while the black wire connects to the negative electrode. A conductor placed between the electrodes permits an electric current.

4. Student Model Development:

After the reaction has run for about 15 minutes, instruct student groups to review their observations and discuss which observations are the most significant.

Next, instruct students to construct an explanation through the development of a descriptive particle diagram. Students will post their particle diagrams to whiteboards, large pieces of white paper, or a digital submission such as Nearpod. Then, student groups will share their ideas during a whole-class discussion.

The checklist on the student activity sheet may provide some scaffolding to students. Students are required to include the following terms in their particle models.

* Solute particles, including charges
* Motion of the particles with arrows indicating motion
* Positive electrode
* Negative electrode

The teacher should travel throughout the classroom, asking students for an explanation of their observations and how their particle diagrams relate to each observation.

After students have completed their diagrams, they may post their diagrams on the wall or stand in front of the class to present them.

*Notes on using the model:*

* The positive copper ions are attracted to the negative electrode where they are changed to copper atoms, forming a clump of copper metal.
* The negative chloride ions are attracted to the positive electrode where they form chlorine gas, which is observed in the pool-like chlorine smell.
* Solvent particles (water molecules) may be excluded for simplicity.