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Conductometer

Physical Science Demonstration Kit

Introduction

Metals are generally considered to be good conductors of heat. However, some metals are better than others. Demonstrate which metals conduct heat well, and which ones do not.

Concept

- Thermal conductivity of metals

Materials

Conductometer*
Wax*
Bunsen burner
Ceramic fiber square, heat-resistant
Razor blade
Stopwatch or other timer
Support stand (optional)
Support stand clamp (optional)

**Materials included in kit.*

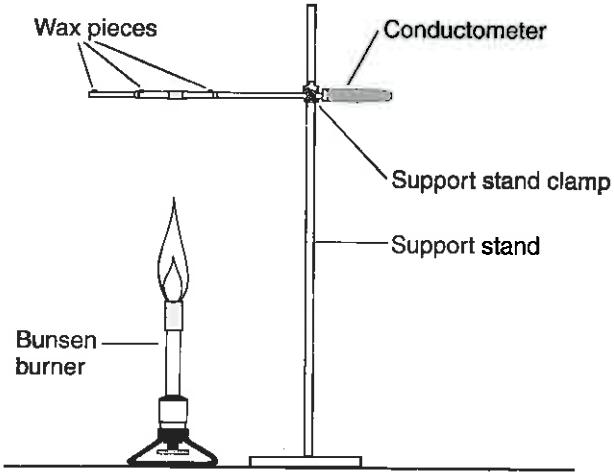

Figure 1.

Safety Precautions

Do not touch the hot Conductometer. Allow it to cool on a heat-resistant ceramic fiber square for at least 10 minutes after the demonstration. Wear safety glasses and heat-resistant gloves. Always follow laboratory safety guidelines.

Preparation

1. Use a razor blade, if necessary, to cut out five small (approximately 0.3 cm × 0.3 cm × 0.3 cm) pieces of wax. The wax tends to be brittle and may crumble. If the wax crumbles, gather the small pieces and press them together with your index finger and thumb.
2. Press one wax piece (clump) in the dimple at the end of each metal spoke. Brush off any excess wax with a paper towel.
3. Obtain a Bunsen burner and, if desired, a support stand and clamp.
4. *(Optional)* Secure the Conductometer to the support stand with the clamp. Clamp as close to the wood handle as possible. Make sure the dimples and wax pieces are on top and the spokes are parallel to the tabletop (see Figure 1).

Procedure

1. Light the Bunsen burner and adjust the flame height to approximately 8–10 cm.
2. Hold the hub of the Conductometer approximately 10–12 cm over the Bunsen burner flame, making sure the wax pieces are on top and the spokes are parallel to the tabletop. *Caution:* Hold the Conductometer only by the insulated wood handle. (If the Conductometer is clamped to a support stand, adjust the height so that the hub is 10–12 cm above the flame.)

3. Students should use a stopwatch, or timer with a second hand, to measure how long it takes for the wax to completely melt in each dimple. Students can enter the time data in a table similar to Table 1.

Metal	Time (s)
Copper (C)	
Iron (steel) (S)	
Aluminum (A)	
Brass (B)	
Nickel–alloy steel (N)	

Sample Results
1 min
4 min
1 min 40 sec
2 min 32 sec
>8 min

Table 1.

4. Once all the wax has melted, place the Conductometer on a heat-resistant ceramic fiber square and allow it to cool for at least 10 minutes. Do not place the hot Conductometer directly on the tabletop. It may scorch the finish or cause a fire.
5. Discuss the results with the students.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The Conductometer and wax (if possible) should be saved for future use. The wax may be disposed of according to Flinn Suggested Disposal Method #26a.

Tips

- This kit contains enough wax to perform the demonstration at least 30 times. Ordinary candle wax may be used as a replacement.
- Match heads can be used in place of the wax pieces to produce a more visible demonstration of thermal conductivity through metal. *Caution:* The match heads may launch off the metal spokes when they flare up. Make sure everyone around the demonstration wears safety glasses and keep combustible materials away from the demonstration area. It may take longer to heat the match heads until they are hot enough to ignite, compared to the time it takes the wax to melt.
- Do not place the Conductometer directly in the Bunsen burner flame. Maintain a height of approximately 10 cm above the flame.
- The melting point for the wax is approximately 55–60 °C.
- For some Conductometers, nickel–alloy steel (N) may be replaced with stainless steel (SS). Nickel–alloy steel and stainless steel have nearly identical thermal conductivity.
- The melting order is: 1. copper (C), 2. aluminum (A), 3. brass (B), 4. iron (steel) (S) 5. nickel–alloy steel (N). For Conductometers with a stainless steel (SS) spoke, stainless steel will be the last to melt the wax. It may take eight to ten minutes for the nickel–alloy and stainless steel spokes to get hot enough to melt the wax.
- Be consistent when determining when the wax has melted when timing the heating process. It is typically easier to measure the time it takes for the wax to melt completely.

Discussion

Thermal conductivity is a measure of how well a substance transfers thermal energy (heat) through itself, and to other matter. The higher the thermal conductivity of a substance, the faster heat transfer will take place. Many metals conduct thermal energy well because they have a large number of mobile electrons. In solid metal, there is significant overlap between the atomic orbitals of the individual atoms in the metal's crystal structure. This overlap allows the valence electrons to drift between the atoms in the solid so that a given valence electron does not "belong" to any particular atom. These mobile valence electrons help with heat conduction because as the metal heats up, the mobile electrons gain kinetic energy and have the ability to travel throughout the metal at a faster rate. The fast-moving electrons "bump" into neighboring slow-moving, "cooler" electrons and transfer some of their kinetic energy to these slower electrons. The energy transfer continues from regions of high thermal energy to areas of low thermal energy until the metal is in thermal equilibrium.